THE ENGINEER

NOVEMBER 21, 1952

The Newcomen Society

THE annual general meeting of the Newcomen Society was held in London on Wednesday of last week, November 12th. The thirty-first annual report of the Council, which was presented by the president, Mr. J. Foster Petree, stated that the present membership of the Society was 454, and that the membership of the North American affiliated society was now over 12,000. The report noted that the relations of the North American Society with the parent Society had been considerably enhanced by the visit to this country, during the summer, of the senior vice-president, Dr. Charles E. Penrose. The report also made fitting reference to the work of Dr. H. W. Dickinson, founder member and past-president, whose death occurred in February last, and who, during the Society's thirty years of existence, had been honorary secretary and editor of the *Transactions*. It is the Society's intention to publish as a memorial volume to Dr. Dickinson, the series of articles which he contributed to THE ENGINEER in 1948, under the title, "Water Supply of Greater London." Mr. J. Foster Petree was re-elected president of the Society, Mr. C. E. Lee was elected a vice-president, and Mr. Max Davies was elected a member of council. Mr. A. S. Crosley continues to serve the Society as honorary secretary. At the conclusion of the business of the annual meeting, Mr. A. A. Gomme gave a talk on "The Centenary of the Patent Office," pointing out that although the Patent Office started its work in 1852, it was not as a direct result of the Patent Law Amendment Act which came into force in that year. Mr. Gomme's talk was followed by a paper on "The Earl of Dudley's Level New Furnaces," by Mr. T. M. Hoskison. The plant described is now part of the Round Oak Steel Works at Brierley Hill, Staffordshire, and has a continuous history covering at least 150 years.

S.S. "Braemar Castle"

THE "Braemar Castle," which is the sixth large passenger-cargo liner commissioned since the end of the war by the Union Castle Mail Steamship Company, Ltd., is the fourth one-class passenger ship to join the company's fleet. Launched on April 24th this year, the ship sailed from London on her maiden voyage in the "Round Africa" service on November 20th, sailing to Cape Town by the west coast and returning via the east coast and the Mediterranean. The ship is of pleasing appearance, having two masts, a single low streamlined funnel, four complete steel decks, and rounded bridge erections, and is the latest of three sister ships built by Harland and Wolff, Ltd. A total of 556 passengers are carried and they are accommodated in single, two, three and four-berth cabins and all share the amenities provided by the comfortably furnished public rooms. These include the lounge, gallery-library, a large smokeroom at the after end of the promenade deck, a children's playroom and an air-conditioned dining saloon, measuring nearly 70ft square and having seating capacity for 288. The main dimensions of the "Braemar Castle" are: length overall, 576ft by 74ft breadth moulded by 35ft 6in depth moulded, and a gross tonnage of 17,029 tons. Subdivision is effected by nine watertight bulkheads, and there are two cargo holds forward and three aft of the machinery spaces. Some of the 'tween deck spaces are insulated and the hatches are served by tubular derricks, including one to lift 30 tons. The main propelling machinery consists of two sets of Parsons triple-expansion double reduction geared turbines, constructed by the shipbuilders, driving three-bladed manganese-bronze propellers. Three Babcock and Wilcox oil-fired water-tube boilers, each incorporating a Howden-Ljungstrom regenerative air preheater and working under the Howden system of forced and induced draught, supply steam at 450 lb per square inch pressure and a total temperature of 750 deg. Fah. Two Cochran boilers supply saturated steam for the hotel services.

Woodworking Machinery Productivity Report

THE report has just been published of the productivity team of the British woodworking machinery industry, which visited the United States last year. This team visited twenty-five firms in America and nine in this country, and it came to the conclusion that the British industry compares very favourably in productivity, quality and design with the American, but that from the best practices in both countries a great deal might be learned. The report points out that with certain exceptions the products of the industry in both countries do not lend themselves to mass production methods, being custom-built in comparatively small batches. On such products, however, the team reports that it saw little evidence of greater overall productivity per man-hour, and that the British industry is better housed and equipped. It is considered that the industry in this country had a great deal to learn from the United States in respect to rationalisation or specialisation of product. Here, too, many firms made too many machine models which overlapped, with consequent smaller batches and higher production costs. It is also pointed out in the report that the American machine manufacturer is more concerned with reducing labour costs than with the saving of materials both in his own works and those of the user of his machines. The British woodworking machine manufacturer, on the other hand, has for long been primarily concerned with the conserving of raw timber because of its scarcity and high relative cost. This has resulted in British designers and manufacturers developing highly efficient and accurate machinery, but possibly of more limited capacity and of less power.

Engineer-in-Chief of the Fleet

LAST week, the Admiralty announced that Vice-Admiral (E) Sir Denis Maxwell, who has been Engineer-in-Chief of the Fleet since 1950, will be succeeded by Rear-Admiral (E) F. T. Mason, who will take over his new duties about the end of April, 1953. Rear-Admiral Mason was born in 1900, and became a special cadet at the R.N. College, Keyham, in 1918, serving in a number of ships, including H.M.S. "Elizabeth," with Admiral of the Fleet, Earl Beatty. In the next few years he saw service in H.M.S. "Malaya," in the engineering department at Malta Dockyard, and the engineering works of Vickers-Armstrongs, Ltd., and was appointed to H.M.S. "Rodney" in 1928 for special service connected with the ship's armament. He was promoted to Commander in 1934, and then spent three years in the department of the Director of Naval Ordnance, after which he joined the "Galatea." In 1939, Rear-Admiral Mason returned to the United Kingdom to take up a newly-created technical and instructional post in H.M.S. "Excellent," staying there until 1943, when he became Fleet Gunnery Engineer Officer, Home Fleet, and was promoted to Captain (E). Shortly afterwards he went to the department of the Director of Naval Ordnance, Bath, and assisted in planning the Pacific war, and two years later joined the department of the Engineer-in-Chief, London, where he spent one year before becoming, in 1947, the Chief Gunnery Engineer Officer and Deputy Director of Naval Ordnance. In 1949, Rear-Admiral Mason became Deputy Engineer-in-Chief, which appointment he held until he became Rear-Admiral (E) on the staff of the Commander-in-Chief, The Nore.

Agricultural Tractor Tests

AT a meeting of the Institution of British Agricultural Engineers, which was held in London on Monday last, a paper entitled "Are Official Tractor Test Results a Realistic Guide to Performance?" was presented by Mr. T. C. D. Manby of the National Institute of Agricultural Engineering. It dealt with the conditions of the British Standard, Nebraska and National Institute of Agricultural Engineering tractor tests, and included some interesting comparisons between the drawbar performance obtained under test conditions and normal working conditions. Mr. Manby said that the days when manufacturers attempted to acquire a sales advantage by conveying an impression of abnormal size and value by quoting a nominal power were, fortunately, almost past, and such attempts led ultimately to disrepute. Sometimes, the "target" or design figures were quoted, but the growing tendency to-day was to quote power figures obtained from confidential, but independent, tests on pre-production or prototype machines. But a wise manufacturer, Mr. Manby observed, quoted a minimum of such figures in his specification, because there was always the difficult passage from pre-production to mass-production, often entailing minor changes, sometimes with unforeseen and far-reaching consequences. The value of the British Standard test report, Mr. Manby suggested, was that it enabled a useful, but narrow, comparison to be drawn between different tractors under certain rather artificial conditions. The value of the National Institute of Agricultural Engineering report was that, whilst fulfilling the function of the British Standard report, it also gave a much wider picture of the drawbar performance to be expected under different agricultural conditions, together with results of a typical day's ploughing and the performance on gradients.

The Shipbuilding Employers' Federation

THE election of office bearers of the Shipbuilding Employers' Federation took place at the annual general meeting of the central board, held in Edinburgh on November 14th. Mr. A. Lewis Cochrane has been succeeded as president by Mr. John G. Stephen, a director of Alexander Stephen and Sons, Ltd., who has been president of the Clyde Shipbuilders' Association for the past two years and is chairman of the African Lakes Corporation. The new senior vice-president is Mr. T. Eustace Smith, the managing director of Smith's Dock Company, Ltd., and who is the fifth generation of the family to be in control of the company. Mr. Charles A. Winn has been appointed second vice-president; he is the joint managing director of C. H. Bailey, Ltd., a director of the Bristol Channel Dry Dock Owners' and Ship Repairers' Federation, Ltd., and a past chairman of the Bristol Channel Ship Repairers' Association. The third vice-president, Mr. Horace Willson, is the chairman and managing director of William Hamilton and Co., Ltd., and is also a director of the Fairfield Shipbuilding and Engineering Company, Ltd., David Brown and Co., Ltd., and Charles Howson and Co., Ltd., and, in addition, is a vice-president of the Clyde Shipbuilders' Association. Mr. Hugh H. Hagan, who is a director of Lobnitz and Co., Ltd., and a member of the board of the Ailsa Shipbuilding Company, Ltd., was elected chairman of the Conference and Works Board, while Mr. R. Cyril Thompson was appointed vice-chairman.

Trans-Canadian and British Railway Experiences

By EDWARD H. LIVESAY

No. II—VANCOUVER TO TORONTO VIA C.N.R.

(*Continued from page* 641, *November* 14*th*)

The author has made a number of recent journeys on Canadian and British Railways and his reminiscences of these trips are set out in this series of articles. They began with a comparison of the two transcontinental railways—Canadian National and Canadian Pacific—giving an account of a journey from Victoria to Vancouver via Nanaimo, C.P.R. This run was the prelude to another from Vancouver to Toronto on the C.N.R., which is described here.

THERE are three railway termini in Vancouver, a city with a population nearing the half-million, yet the number of trains using them seems to the uninformed extraordinarily small. It will sound very strange to readers familiar with the heavy traffic handled by most British termini to be told that only three trains in each direction use the palatial Canadian National Railways station (Fig. 5) every twenty-four hours, and one of these is merely the second section of the "Continental." Even this modest tally is strictly speaking an overstatement, as the third train only runs twice a week—"out" Tuesday and Friday, "in" Wednesday and Saturday. Company officials are somewhat apologetic about this state of things, admitting that it is a pity more use cannot be made of this impressive pile, in which, however, the Western Divisional offices are housed. But nothing can be done about it; the company can hardly be expected to put on more trains to suit the station, nor merely to give the staff more to do. The fact remains that on three days a week—Sunday, Monday and Thursday—the station goes to sleep—so far as traffic is concerned—between the arrival of the two sections of the "Continental" at 7.45 and 8.45 a.m., and their departure at 7.30 and 8 p.m. that evening. Twice during the week, however, business perks up a little; on Tuesdays and Fridays, train M398, "mixed," leaves at 9 a.m. for Boston Bar, the first divisional point to the east, a diminutive little town perched high above the Fraser River on a buttress of the canyon, where it arrives at 7 p.m., after covering the intervening 132 miles in 10 h. On Wednesdays and Saturdays it returns as No. M397 at 3.30 p.m. in only 8 h 45 min; it is downhill coming west, and hence the higher speed and 1 h 15 min faster time. The sum total of trains using this fine station is therefore thirty-two per week.

The Great Northern Railroad station—part of this is seen on the left of Fig. 5—from which trains leave for Bellingham, Seattle, Portland, &c.; it is an American line—does even less to justify its existence, only two trains per day in each direction being scheduled, twenty-eight weekly. The Canadian Pacific Railway, the senior partner of the Vancouver trio, does considerably better, with seven trains in and out on weekdays and six on Sundays, making a total of ninety-six for the week. This meagre number of trains serving such a large city is due to the fact that the total population of British Columbia is not much over a million, half living in two centres, Vancouver and Victoria, and there are very few other towns of any size within reasonable distance. It follows that less travelling is done than in Britain, and further, a considerable amount of traffic goes by road and air. The number of passenger trains available is not likely to increase in the future—on the contrary.

From this it is not surprising that going to the C.N.R. station in Vancouver to purchase a ticket* always seems to me something of an ordeal; there is an impressiveness about the vast echoing Concourse that almost impels one to cross it on tip-toe, and lower one's voice at the ticket window. One has a feeling of insignificance in this majestic pavilion that is somewhat disconcerting. However, mastering this recently, I found myself with "transportation"* arranged, and settled in a tourist sleeper. The "Continental Ltd." left punctually at 7.30 p.m. and I looked forward to a comfortable night's rest in a lower berth, locomotives forming no part of the programme until next day—and not even then if they could be avoided!

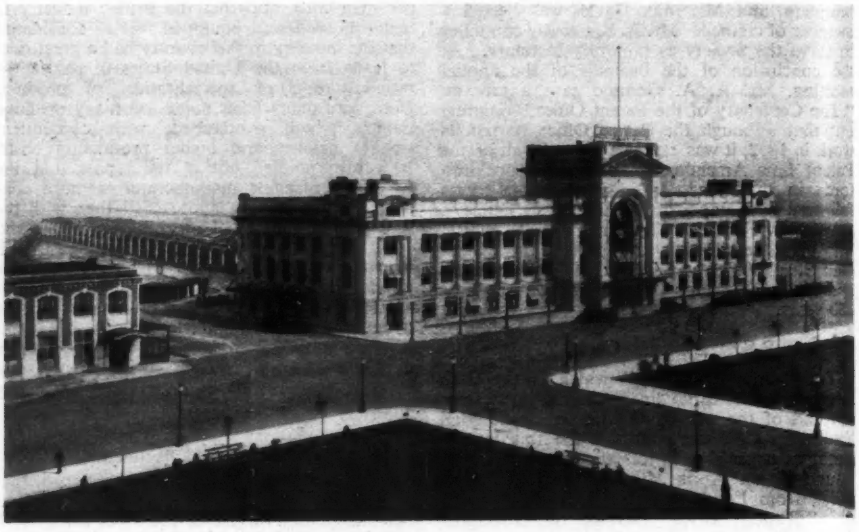

Fig. 5—Vancouver Station—C.N. Railways

Since I last travelled east on the "Continental Ltd." during the war, changes and improvements have naturally been made in its equipment, both as to motive power and rolling stock. The latest type of all-steel car is used, running on twelve wheels, and weighing about 80 tons; the old "Pacific" engines, all that bridges and track would stand between Vancouver and Kamloops Junction, have given place to the larger 4–8–2 "Mountain" class, No. 6000 and upward now that the permanent way is fit to carry them, and they run right through to the coast. No. 6028 (Fig. 6) happens to be the engine that hauled the Royal train over C.N.R. metals in 1939; the Royal Arms will be seen beneath the headlamp. They are fine engines, with 6ft 1in drivers, and a tractive effort of 52,000 lb, which do most of the passenger work from Vancouver, through the Rockies, and all the way east to Toronto and Montreal. From the picture it will be noticed that Walschaerts valve gear is fitted, and as in the past Baker gear was almost standard on C.N.R. engines, I made inquiries as to the reason for the change-over. It seems that the heavy component parts of the Baker gear, with its long-lap valves, coupled with the large angular movement and excessive eccentric crank throw necessary to obtain the long travel for which the Baker gear is noted, set up severe vibration at high speed. It was found that properly designed Walschaerts gear arranged for correct valve events could give 7½in valve travel without this objectionable angular movement, excessive crank throw or vibrational stresses. Walschaerts details have the advantage of being readily shop made—there is no question of patents involved, as with the Baker gear. The C.N.R. locomotive staff admits, too, that a certain amount of personal prejudice is apt to enter the picture—how true this is of many details of locomotive design! The following table gives the respective crank throw and valve travel of Walschaerts and Baker gears fitted to representative C.N.R. locomotives :—

Walschaerts Gear

Type	Crank throw	Valve travel	Drivers	Class
	In	In	In	
4–8–2	16 7/16	7⅜	73	U–1–f
4–8–2	16	7⅜	73	U–2–g to h
4–8–2	17⅛	7½	73	U–3–b

Baker Gear

Type	Crank throw	Valve travel	Drivers	Class
	In	In	In	
4–6–4	25	9	80	5700, K–5–a
4–8–2	25	9	73	U–1–e
4–8–4	25	9	77	U–4–a
4–8–4	20	8½	77	U–4–b
4–8–2	23½	9	73	U–3–a
4–8–2	23½	9	73	U–2–a to f

* Should you visit Canada and travel by train, do not be stumped if the conductor stops beside you and says: "Let me see your transportation, please." He means your ticket. This is the latest inanity that has crossed the 49th Parallel and invaded Canada from the south; any silly phrase or habit, and their name is legion, adopted there is sure to drift north sooner or later—this is one instance. In the States changes are often made for the mere sake of change, not because change is advisable, and Americans love using a big word where a small one will do. "Ticket" has done duty for many years, is simple and satisfactory—therefore, change it to something clumsy and silly. If you do not fully grasp the assininity of this word, imagine the guard of a British train coming along and saying, "Transportations, please!"—E.H.L.

Fig. 6—" U1 " Class Locomotive

The leading dimensions of these ubiquitous engines are :—

Cylinders	24in × 30in
Valve gear, Baker :	
Diameter	12in
Travel	9in
Lap	1¼in
Lead	¼in
Exhaust clearance	⅛in
Driving wheels	6ft 1in
Heating surface :	
Superheater	1,040 sq ft
Total	4,940 sq ft
Grate area	66·7 sq ft
Steam pressure	250 lb
Weight on :	
Drivers	103 tons
Engine	158 tons
Tender	123 tons
Total	281 tons
Tractive effort	52,000 lb
Tender :	
Water	11,000 gallons
Oil	4,000 gallons ; or
Coal	20 tons

The later locomotives have Vanderbilt tank frame tenders, two siphons, an exhaust steam injector (or feed water heater when the former is not used), multiple throttle, Nathan lubricators, floating bushes to truck and main driving axles and track sprinklers.

On this occasion, the " Continental Ltd." was headed by engine No. 6010, the load was fourteen cars—say, 1200 tons—all twelve wheelers. There was no pilot engine to help the train over the steep 1 in 100 bank just outside the city, between it and New Westminster, as was always the case when a " Pacific " handled the train ; the " Mountains " are capable of doing the work single-handed. We left promptly at 7.30 p.m., for the first few miles running over Great Northern metals. The heavy rise mentioned above is the only gradient heavier than 1 in 300 right through to the Yellowhead Pass in the Rockies, I believe, with the possible exception of the approaches to the mile-long bridge over the Fraser River at New Westminster. This is delta country, with the usual low river banks, so in order to give shipping headroom the line rises at 1 in 100 on both sides of the bridge. New Westminster is the first city of any size and importance after leaving Vancouver, 13 miles ; it has a fine fresh-water harbour, huge canning factories—it is, in fact, the centre of the Fraser River salmon canning industry—lumber and shingle mills. Once across the Fraser, at Port Mann, the original terminus of the Canadian Northern Railway, the " Continental " takes to its own company's metals.

It should be explained here that the C.N.R. is Government owned, becoming so by the amalgamation of two systems, the Canadian Northern, and the Grand Trunk Pacific, the former privately and the latter State operated. The Canadian Northern was no sooner built through to the coast than it threw up its hands, and as it could not be allowed simply to go out of commission, the Government had to take it over and merge it with the G.T.P., changing the name to Canadian National Railway. Hence the two Pacific termini, the southern one, at Vancouver, being originally the Canadian Northern's coastal extremity, and Prince Rupert, 600 miles north, once serving the G.T.P. in like manner. The Canadian boom at the beginning of the century was responsible for the grandiose idea that the rapid expansion of the country's trade, industry and population made three transcontinental lines desirable and feasible—the third being the existing Canadian Pacific. Of course, there was no justification for the two additional lines ; neither paid nor ever could pay until the population reached at least 25 million ; it is only 14 million now, forty years or more after the three transcontinentals came into being. The predicted flood of traffic pouring both ways across the country has never materialised, and now shows less prospect than ever of doing so, with road and air transport, neither taken into account half-a-century ago, cutting into railway revenues more and more every year. Certainly two trunk lines across Canada were all that conditions ever justified, or are ever likely to, but now the three exist—counting the C.N.R. as embodying two—and must be kept in operation, if only for the sake of the territory served and the population settled therein, that still depends on the railways for existence. They exist, too, only at the expense—so far as the national line is concerned—of the taxpayer, and ironically enough, he is often a Canadian Pacific taxpayer living beside the line that is always complaining of the unfair competition of the State-owned system ! He has got his national railway and now it is up to him to pay for it, which he did to the tune of £200,000,000 between the two wars. But enough of politics—we are in the " Continental " travelling eastward ; what are we coming to ? Fort Langley, 28 miles from our starting point ; this little place and others along the Fraser prove that even British Columbia has a history. It was the first trading post established by the Hudson Bay Company in British Columbia, the date being 1827, and here, too, in 1858, Sir James Douglas was sworn in as the first Governor of the newly created Crown Colony. I need not describe this section of the journey very fully as it was dealt with in " The End of an Era " articles in THE ENGINEER of November/December, 1951, and in any case darkness was falling. Hope can be given a word or two ; it was here that the first gold discovery was made in 1856 and, two years later, the great Cariboo gold rush started, bringing 10,000 miners into the Fraser Valley, and leading to the construction of the famous Cariboo Trail, the road beginning at Yale and following the left bank of the river, where traces of it can still be seen clinging to the side of the Canyon. Just below the town Hill's Bar was staked one of the richest claims ever worked in the Cariboo. Yale, incidentally,

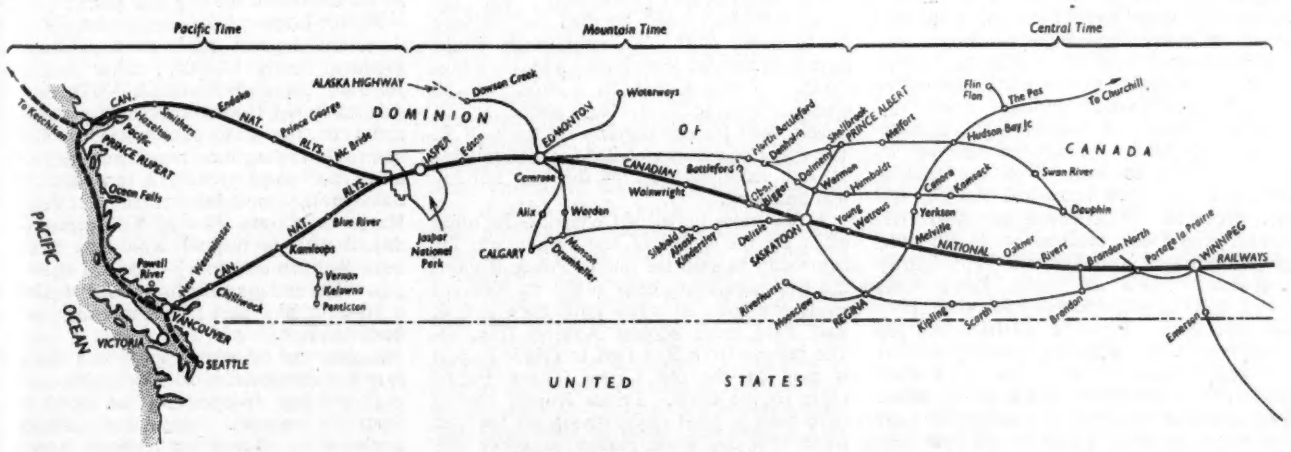

Fig. 7—C.N.R. Western Division

is at the head of navigation of the Fraser. A few miles farther is Boston Bar, the first divisional point, 132 miles from Vancouver, where we came to a stand at midnight—29 m.p.h. The name is a reminder of the Gold Rush days, when river bars were panned and claims named after their owners—China Bar, Dutchman's Bar, and so on. Here I definitely gave up note-taking; for some time I had been luxuriating in my berth, looking out at the Canyon, down into the misty Fraser, glittering under a full moon, sometimes seeing on a bend the headlight tunnelling ahead and lighting up the wet rocks, turning the vegetation to a vivid green, or across on the other side of the Canyon a C.P.R. train—probably the eastbound "Dominion"—winding along its shelf like a glow-worm. I thought "How much better to take notes from one's berth than from the cab! Far more comfortable and, after dark, just as effective!" By the time we reached Lytton—named after Lord Lytton, the novelist, who was Colonial Secretary when the gold rush started in 1858—just before which the Fraser was crossed and recrossed, I had passed beyond all railway cares and knew nothing more until coming to at Kamloops Junction, the next divisional point, at 7.30 a.m., finding that we were three hours late. The reason—a broken drawbar, which happened during the small hours without waking me, strange to relate. A little way back, near Tranquille, the train had passed through the longest tunnel, 2827ft, on the Canadian National Railway west of Montreal, where there is one under Mount Royal, leading to the new terminal in the heart of the city.

It seems curious to a British visitor to notice how little tunnelling is done by any of the railways crossing the continent, which shows how very level the terrain is once the Rockies have been passed. The C.N.R. has no tunnels even there, and scarcely any worth noticing right to the Atlantic save the Montreal bore already mentioned.

Kamloops is on the opposite, left, side of the Thompson River to the main line, and a branch is taken across to the town, but the "Continental" remains on the right bank, stopping for half-an-hour at the Junction for servicing, &c., and then follows the North Thompson over the next division to Blue River. In British Columbia railways generally follow the rivers, which is often the only way to get through the sea of mountains that constitutes two-thirds of the Province. I was still doing my observing through the windows of my car and across the breakfast-table in the dining-car rather than from the cab; the outlook, though rugged, was not so impressive as in the wonderful Fraser and Thompson Canyons, yet it was interesting and worth looking at, becoming much more so at Messiter, where Little Hell's Gate was entered, the outlet of an 8-mile Canyon through which the Thompson boils and tosses, bringing disaster in 1863 to a party of miners on their way to the Cariboo gold field, when the leading rafts of several were upset and many of the men drowned. Blue River, the third divisional point, was reached at 11.30 a.m., 35 minutes late, and Pyramid Falls shortly afterwards, where the water drops 300ft into a bowl so close to the track that spray wets the train. We were 2304ft above sea level here, after climbing steadily almost the whole distance, 426 miles from Vancouver. Canoe River passed shortly after, was much in the news a year or so ago; two trains staged a head-on collision here due to the omission of two vital words from a "Train Order." The story is interesting and points a moral, showing as it does that in spite of precautions designed to rule out the possibility of error, the "human element" is apt to intrude, nullifying the safeguards, and resulting in disaster. It also shows that the telephone is less to be depended upon than the telegraph; it is strange the railway people had not discovered and acted on this long before.

The wreck involved the eastbound "Continental" and a west-bound Special, carrying troops *en route* to Korea. The "Train Order," which a young telegraph operator had received over the 'phone, written down and handed to the conductor of the Special, lacked two vital words—"at Cedarside," where the two trains were scheduled to pass. The order was intended to read: "Passenger extra 3538 (the troop-train) meet No. 2 (the 'Continental') Engine 6004 at Cedarside and No. 4 (second section of 'Continental') engine 6057 at Gosnell." Omitting the words "at Cedarside," it will be seen that the order directed the Special to meet *both* the eastbound "Continentals" at Gosnell, and this is how it read as handed to the conductor of the troop-train. The result was a collision, on a bend as bad luck would have it, where evidently neither engineer saw the other train until it was too late to do anything, and the death of the enginemen of both trains and seventeen soldiers resulted.

It should be said that the 'phoning of "Train Orders" is not, and has not been the usual system of transmission in Canada, but it happened to be in this instance. The chances of mistakes being made over the 'phone are too great; as a rule orders are telegraphed, which allows the imposition of various checks and safeguards not possible where the telephone is employed. For instance, once the message is written down the number of words, also stated in the message, can be checked; had this particular order been handled in this way the omission of the two vital words would have been noticed, looked into, and correction made. I believe that, as a result of the Canoe River accident, the 'phone is no longer used for this purpose on the C.N.R. The operator was prosecuted for manslaughter, but acquitted, and in the end nobody was punished.

A few miles north of Cedarside the track picks up the valley of the Fraser and far below can be seen the line to Prince Rupert, the two paralleling each other at different levels for over 20 miles until they join at Red Pass, near Mount Robson (Fig. 8). The railway from Red Pass to Prince Rupert is part of the old Grand Trunk Pacific route to the coast. Prince Rupert was to have been a great city thriving on the vast trade that for some reason or other was inevitably destined to flow through it; wheat to China, for instance, where they only eat rice; possibly cherries to Japan, and so on—anything goes when boosters want to build a railway. But something went wrong, and the trade never materialised; Vancouver grabbed most of the increment and the rest never existed, so despite its fine harbour—though with a rock bottom—the port has never attained the stature enthusiastic real-estate agents with town lots to sell in the surrounding bush prophesied for it. The climate is beastly, for one thing—or so I think—with125in of rain a year. But in any case the line was built from the mountains 700 miles to the Pacific, at a cost of tens of millions of dollars—when the dollar was worth a dollar and not about 50 cents as at present—yet, after all this toil and all these years, forty or so, only three passenger trains per week in each direction use it! The Prince Rupert terminus must be even more a home of rest for the staff than the one at Vancouver. Only the fact that I know the C.N.R. people at the coast have a sense of humour makes it safe for me to let the cat out of the bag like this.

Fig. 8—Mount Robson and "The Continental Limited"

Mount Robson has been in view for some time, the highest peak in the Canadian Rockies, nearly 13,000ft; after Red Pass Junction comes Yellowhead, 3717ft, on the Alberta-British Columbia boundary; it gives name to the wide pass which the C.P.R. ignored in the 'eighties because it was too far north, but which provides a far easier route through the mountains than the Kicking Horse or Crows Nest. Yellowhead was named after a trapper who had a cabin near Robson a century ago and used the pass when bringing his furs to Jasper House, a Hudson Bay post; it happened he had flaxen hair.

Jasper, the divisional point, was the next stop; it stands at 3470ft, so we were over the peak and had dropped 247ft in the 18 miles from Yellowhead. Here the oil-burning engine came off and was replaced by a coal burner of the same type, 4-8-2. The

"Continental" left at 6.23 p.m., nearly 4 h late, none of the time lost by the breaking of the drawbar having been made up; on the contrary. We were now running on Mountain time, after being on Pacific from Vancouver. It was raining heavily, quite a change from Victoria's drought that had lasted most of the spring. On the gentle down gradient the "Continental's" speed rose into the 50s and 60s, and once again I settled down into my berth, looking out at the farmlands through which the train was running, and the fine motor road that keeps touch with the railway right to Edmonton. Much of the road was made from the abandoned grade of one or other of the two trans-continental lines that ran in parallel for hundreds of miles across the prairie and through the Yellowhead—a crazy business if ever there was one. When amalgamation took place the grades were used indiscriminately, whichever of the two happened to be most desirable, and the rest discarded, as can be seen at many places between the Mountains and Edmonton. At Bickerdike a spur line goes south to the coal mines at Rocky Mountain Park, which have just gone out of operation; another example of the writing on the wall—the future is with oil in Western Canada.

Looking to the north from the train, one sees an austere country, to me almost ominous, which attracts yet repels me, both. A vast stretch of stunted fir extending to the skyline 50 miles or more away, across a series of low rolling hills, showing no sign of life; no towns, farms, roads; just this endless expanse of dull, green vegetation fading into infinity, stern, empty. I surveyed up there far to the north forty years ago, and have never revisited the scene of my labours since, though I always meant to; some day I will before it is too late. I want to see what has happened up there Have farms been hewed out of that wilderness; are there oil derricks, roads, villages? Yes, I understand all of these signs of civilisation can now be found near or in those very townships I helped lay out, but they were not visible from the "Continental" this dull and overcast evening. I thought of this primitive country as I saw it locked in winter's grip long years ago, when blizzards howled over it, and to be caught out in one away from shelter meant death; when only the tracks of mink and fox sullied the white mantle that muffled this wilderness for six months on end. There was nothing there then; it was the world as God made it; from the train it looked as lonely and empty as when I first saw it in 1910, and drove location stakes into its primitive soil—the self-same stakes the settlers doubtless have since found, and are still finding and using to tell them where they are. That floating muskeg across which—against every rule of the surveyor's creed—I tried to walk "to save time," breaking through and was nearly drowned; is that still there, or has it dried up? Many changes no doubt have taken place up there, but nothing to those that will be seen in the near future. This is the Last Great North, the expansion and exploitation of which has finally begun, helped by the discovery of uranium and oil. Well, I was among the first to go in there—I helped survey some of this jungle—but so long as I retain my senses I will never live there.

While I mused thus the Athabaska and McLeod rivers were crossed by steel and trestle bridges; Edson, another divisional point, was left behind as darkness fell, and Edmonton finally reached nearing midnight, several hours late. I paid no attention, having decided not to stop off there, or, in fact, anywhere short of Saskatoon, 566 miles east of Jasper, though Edmonton would have made a good rest-and-be-thankful, with friends to visit, and the nearby oilfields to investigate. It is the Provincial Capital, with a population well over 125,000 and always increasing; it has not only a romantic past, but an assured future. It is the jumping-off point and supply base for the vast northern territory extending up to and past the Arctic Circle, whose resources are as yet only beginning to be exploited. The Alaska Highway really begins at Edmonton (Fig. 7), and will bring the Peace River country, and Alaska and the Yukon, into road communication with the city as soon as it is hard surfaced. Railways radiate from Edmonton in every direction, oilfields apparently surround it—the famous Leduc wells are only a few miles to the south, the field that drew the world's attention to the limitless oil potentialities of Alberta. Many of its houses are heated by natural gas, a system with which I first became enamoured at a friend's residence; surely there can be no better method of heating and cooking conceivable. Ashless, odourless, smokeless, one merely lights the burner in the basement heating plant in the autumn, and there is nothing more to be done until one turns it off in the spring, thermostatic control holding the temperature at whatever is desired all over the house. No dirt, no work, and a warm house despite possible 60 deg. below zero frigidity outside. No strikes to cut off supply; only the exhaustion of the vast natural reservoirs, the possibility of which nobody seems to bother about.

(To be continued)

Otto and the Otto Engine

By Dr. GOLDBECK*

The Klockner-Humboldt-Deutz A.G. is the lineal descendant of the firm N. A. Otto & Cie set up by Otto and Langen at Cologne in 1864, *and of the Gasmotoren-Fabrik Deutz A.G. set up by Langen in* 1872. *For this article Dr. Goldbeck has drawn heavily on the firm's unrivalled records of, and researches into, the life of Otto. The histories of Otto's inventions of the "atmospheric" engine and the four-stroke cycle engine are traced and the question of Otto's priority as an inventor is discussed.*

INTRODUCTION BY THE EDITOR

ABOUT a year ago there appeared in this journal a leading article on "The Otto Celebrations at Cologne." The Klockner-Humboldt-Deutz A.G. felt that, though factually correct, the article gave an unfair impression of Otto's character and of the importance of his work. In these circumstances it seemed only fair to us that the firm should have the opportunity to put on record in this journal the facts gathered from its extensive records and the conclusions that have been drawn from them. We are now happy to print this account by Dr. Goldbeck. That there has existed, and still exists, disagreement amongst historians about Otto's standing as an inventor is merely an illustration of the fact that it is humanly impossible even for the most learned and meticulously accurate historian to prepare from the often biased, contradictory and inaccurate documents that survive from the past an account that is unchallengeably truthful. Moreover, every nation's historians, if only from greater familiarity with them, tend to be naturally biased in favour of the claims of their own nationals. Furthermore, a reader of a document written in a language other than his mother tongue is open to the error of misconstruing not its literal meaning, but its underlying argument and thus receiving an impression about past events that is not truthful. As a reference in the following article makes clear, Dr. Goldbeck has so misconstrued the argument of our leading article of last November. It did not present Otto in the unpleasant light of an "entrepreneur who was lucky enough to find expert associates, and who tried to use the work of others for his own profit and honour," as Dr. Goldbeck suggests it did. It did remark that he was "peculiarly blessed in his associates." So, incidentally, was James Watt in his association with Boulton. It did, indeed, dispute Otto's priority in invention, but not his greatness nor the sustained and successful labours which he put into the development of the gas engine. Certainly it did not suggest that Otto tried to divert the work of his associates to his own profit and honour or that he knowingly drew upon the works of prior inventors and claimed them for his own.

Of the documentary accuracy of this account by Dr. Goldbeck there can be no doubt whatever. The Klockner-Humboldt-Deutz concern has made a particular study of the history of the development of the Otto engine and the life of Otto. Whether or not readers with knowledge of the subject will find Dr. Goldbeck's arguments, based upon the facts, satisfying is, of course, quite another matter. But that does not concern us. Our job, when more than one opinion is held about such a subject, is to ensure, as far as we are able (even if we ourselves lean to one side or the other), that the arguments upon each hand are fairly and equally presented. What no one doubts is that Otto was the great pioneer of the gas engine and virtual founder of the gas engine industry.—ED., THE E.

The mathematician Whittaker once said about the history of natural science and technology: "Believe me, hardly any discovery is actually due to the man who is quoted in the textbooks." But nevertheless we may have confidence in the leading historians' accounts of N. A. Otto, the originator of the four-stroke engine. Yet, though the facts have been well established for the past seventy-five years many a writer still feels obliged to seek the "true" inventor of the internal combustion engine, devoting extremely careful attention to inventions which remained without practical realisation, but less careful attention to the real developments. They fail to notice important characteristics and deeds of the inventor, N. A. Otto, because they are searching for rills which oozed away in the sands, and do not draw water from the well from which the mighty stream of motorisation has really flowed.

The circumstance that Otto was a merchant has led to the misinterpretation that he was merely a farsighted entrepreneur who was lucky enough to find expert associates, and who tried to utilise the work of others for his own profit and honour.[1] When in 1864

* Klockner-Humboldt-Deutz A.G.

Otto founded the firm of "N. A. Otto & Cie," together with Eugen Langen, whom he did not know up to that time—friends had arranged their meeting—he contributed to the company "one gas engine in operation, two in course of manufacture," besides patents registered in Great Britain, France and Germany.[2] Nature endows an inventor with inventive talents, quite regardless of his profession, which is prescribed by fate. In this case, it was the merchant Otto who was the inventor. The engineer Langen was the entrepreneur.

The Atmospheric Engine

The "atmospheric engine" of Otto und Langen was identical in principle with Barsanti's engine. In 1857 Barsanti had filed a patent for an atmospheric engine, several designs of which he had so far developed, together with Matteucci, that they could be operated. But the designers did not succeed in introducing the engine into practice. In the spring of 1864, Barsanti tried to gain Messrs. Cockerill's interest in his plans, but unfortunately a sudden illness brought his life to an end when he was staying at Liege.[3]

Barsanti's death occurred a few days after the company, "N. A. Otto & Cie," was established in Cologne. There is nothing to indicate that Otto knew of Barsanti at that time and it is quite certain that he did not know of his achievements. Otto, in fact, invented the atmospheric engine independently. In 1861, a Cologne mechanic built a gas engine on the basis of Otto's data according to the Lenoir system. When experimenting† with this machine Otto made two observations, which he described as follows :—

"Taking the quantity of mixture sucked in with a quarter of the piston stroke, I observed that the piston only seldom passed the dead centre. After each effect it arrived near the end of its stroke and was then pulled back in the same way. After the first trials of starting the engine had failed, I knew the cause thereof ; the burnt gases cooled down much more than I had calculated. I altered the machine in such a way that I could suck in the explosive mixture on one half and even three-quarters of the piston stroke. At half charge the small engine continued running, at three-quarters charge its operation was even worse, which again was easy to explain. I then found the right idea : ignition and combustion must take place at the beginning of the piston stroke, and this idea was at once successful. I sucked in explosive mixture to one-half and eventually three-quarters, tried to press the piston back as far as possible by turning the flywheel backwards, then I ignited and, behold, the flywheel vigorously rotated several times. That was the starting-point of a four-stroke gas engine. In that very year the drawing of such an engine was completed."

However, the explosions produced in this four-stroke engine were so violent that at the end of a few months the engine was destroyed. But Otto did not cease striving for his aim, an economical internal combustion engine, and took the first of the above observations made on the Lenoir engine : the atmospheric principle, the formation of a space containing rarefied gases, the pressure of which was less than that of the atmosphere.

Gasmotoren-Fabrik Deutz A.G.

The experiments had exhausted Otto's pecuniary resources. In the person of Eugene Langen he found the entrepreneur who had studied technology and procured the means for continuing the work. They jointly completed the engine. Langen designed the free-wheel clutch, the component of vital importance for the life of the engine. Later on Otto and Langen recognised Barsanti's priority but considered the value of their own work as important since it led to practical realisation. As Dugald Clerk writes, the Germans succeeded economically and scientifically where the Italians had entirely failed[4]. In 1872 Eugen Langen founded the "Gasmotoren-Fabrik Deutz A.G.," of which Otto was appointed managing director. Langen thought that a skilled production engineer should take over the management of the large factory workshops as, in his opinion, the inventor Otto was not the right man for this job. Gottlieb Daimler, summoned from Karlsruhe, was appointed technical director. Wilhelm Maybach came with him as chief of the designing department. Production was the firm's prime interest and was actively pressed by Daimler. The design of the engine was simplified without changing its principle. A total of 5000 units was manufactured. A beginning was thus made in the economical use of internal combustion engines by industry.

Otto, it will be noticed, was ousted from the technical sphere. But he still felt destined for technical activity though he had never been inside a technical college. Bitterness was thereby bred and conflicts with Daimler, a man of different character were unavoidable. Thus, whilst Langen, Daimler and Maybach attended to their daily business, Otto brooded and observed untiringly what was going on in his engine. The noisy operation and the restriction to performance of up to 3 h.p. remained insurmountable disadvantages. Other inventors did not rest either, and in 1875 the hot-air engine, known in principle for a long time, appeared at last to have been developed into a serviceable power machine. Langen's fellow-student, Reuleaux, Professor at the Berlin Technical College, warned him against the new competition and he summoned "all hands on deck" at Deutz. This call was, in reality, hardly necessary, for Daimler and Maybach were already endeavouring to improve the engine. But they kept to the atmospheric principle. In particular they tried to replace the rack and the free-wheel clutch by directly linking the piston to the engine shaft. As may be understood under these circumstances, however, nothing was done to cause the business friends of the works to lose confidence in the old design. By contrast, Otto reverted to the study of his engine of 1862, the so-called "high-compression engine," which had run on the four-stroke cycle. Reuleaux had recognised the true principle of this invention, and in the above mentioned letter he said : "What has to be done, however, is that the high-compression engine must at once be brought to the foreground and put into practical shape. The Daimlerisms have to be buried in the files once and for all."[5] Otto succeeded in standing his ground against Daimler and began the building of an engine on his own. A new engineer, without any experience in engine construction, carried out construction and tests according to Otto's instructions. In a very short time the first engine was completed. It immediately proved successful, uniformly and reliably producing 3 h.p. at 180 r.p.m. That this was the origin of the Otto engine is made clearly obvious from the works records. Neither Langen nor Daimler ever put forward any claim relating to the invention.

Attacks on Otto's Patent

A long period of searching came to an end with the creation of "Otto's New Engine" (Otto Silent). In this engine the first real internal combustion engine was produced. Now no other type could survive. Attempts were therefore soon made to attack Otto's patent and to cancel his rights. During this campaign inventions that had been ineffective and papers long since forgotten were brought to light.

Reithmann.—By citing a gas engine designed by the watchmaker Christian Reithmann, of Munich, it was hoped in vain to prove priority over Otto in the invention of the four-stroke cycle. Between 1860 and 1870 Reithmann had built an atmospheric engine. But he failed to perfect it. Over a period of years he applied some modifications, but after 1874 he ceased to inform other engineers about this engine. In that year Reithmann negotiated with the engineer Will for the manufacture of an engine, but only a horizontal engine of a former, entirely different, design was then concerned. The Court later deduced therefrom "that one certainly would have recommended and accepted the vertical engine as the better one, if it had already represented the more perfect Deutz system, and that it was incomprehensible why Reithmann did not point to the better design which was said to have existed."[6] Reithmann then left the engine in an unserviceable state for several years, until in 1883 it was cited, against his will, during the litigation by the competitors of the Gasmotoren-Fabrik Deutz. The investigations showed that the machine could operate on the four-stroke cycle if its compression ratio was lowered and an electric ignition system was fitted. The engine was then provided with a piston and piston rings never previously used. It had never previously been equipped with electric ignition. The sparking plug was newly produced, and the hole for insertion in the combustion chamber was newly drilled. All the experts called it an "uncompleted trial engine." Reithmann maintained that the engine had run before 1880, but with a gas ignition, which he constantly refused to renew. The vague evidence of the witnesses referred to the outer appearance only and was not based on any knowledge of the interior function. It remained undisputed that the machine was "usually out of service" and "never in strenuous operation." A picture published from time to time[7] and said to represent the machine as a four-stroke engine in 1873 was not produced during the proceedings. In the first instance the Court decided against Otto. Reithmann, however, does not seem to have been certain of his case, for otherwise he would not have ceded to Deutz for a considerable sum the engine with any rights of prior use which might be based upon it, without awaiting a decision of the Court of Appeal.‡ He would not have been able to achieve this financial success later on ! For the Court of Appeal denied Reithmann's priority. He himself could not definitely state when he had used the four-stroke cycle. The judgment given in the first instance was objected to, as having attached more importance to the similarity to the Otto engine of the repaired Reithmann

† Very briefly the "atmospheric" engine sucked in air and gas and the mixture was ignited about midstroke. As Otto found out, with a limited charge the piston was not pushed to the dead centre but sucked back into the cylinder.

‡ That Mr. Reithmann was aware that his priority claims were badly founded and that the judgment favourable to him had not fully taken into consideration all the circumstances which speak in Deutz's favour may be deduced from a remarkable paragraph in correspondence between Mr. Reithmann and the Gasmotoren-fabrik Deutz. It reads as follows:—"The Gasmotoren-fabrik Deutz agrees that it will not compromise Mr. Reithmann in any way in a circular or in other publications issued by them." The sense of this agreement can hardly refer to Deutz as publishing untrue assertions. Facts, it suggests, had become known, the further circulation of which could have morally damaged Mr. Reithmann.

engine of 1883, than to the statement of the time at which Reithmann converted the engine to the four-stroke cycle. It clearly results from this lawsuit that no evidence was furnished of priority to Otto's second and this time more successful invention. Moreover, no expert contested the fact that the engine, even after having been equipped with a better piston and another ignition system, was still far from a serviceable prime mover. The development of the machine had got stuck at the trial stage, and Reithmann himself had stopped working on it by 1880. The machine, in the writer's view, gained importance only through the patent lawsuit, without which it would probably never have attracted any attention.

The precedence of the Otto engine over the Reithmann engine in the development of the gas engine is particularly stressed by A. K. Bruce in an article that is well worth reading.[8] Unfortunately, however, he has misunderstood some of the German sources. He gathers, for example, from an article by A. Langen entitled "60 Jahre Viertaktmotor" ("Sixty Years of Four-Stroke Engines") that Professor C. von Linde had seen the so-called "four-stroke engine" of Reithmann's as early as 1874. The relevant passage in the German text runs as follows: "It is now certain that Linde, who had examined the engine in the old state in 1872, saw it again in the same condition in 1874 at Reithmann's." By this "old state," however, the design is meant which never ran on the four-stroke principle. The records of the lawsuit show that in a public lecture in 1874 Linde spoke disapprovingly of this old design. The verdict of the Upper Court refers to a statement by Linde in which he said that in 1874 "if he had found a new working principle, he would not have overlooked it and would still be able to remember it." Bruce furthermore refers to an article by the engineer already mentioned, Will, which appeared in *Praktischer Maschinen-ingenieur von Uhland* (1874, page 93), which describes the horizontal engine of the old design and claims for it that "it surpasses all the systems known hitherto." Reithmann only publicly explained those designs of his which were drawn up prior to 1874. In a notarial statement (December 18, 1884) Reithmann confirmed that "prior to 1880 he had given neither information nor indication of this engine to any other person, nor had he publicised it in any way by drawing or description. On the contrary, he deliberately kept it secret." The statements of witnesses, therefore, could only refer to external appearance.

Beau de Rochas.—The patent opponents further found a French engineer's paper a few copies of which were published in 1862. Almost at the same time as Otto tested his first four-stroke engine, Alphonse Beau de Rochas clearly described the four-stroke cycle in a voluminous paper on improvements in railway technique.[9] The patent granted[10] in his favour was not published, because he did not pay the fee, and nobody ever tried the cycle. For the paper written by Beau de Rochas was not clear enough to be understood by contemporary engineers. It would have been an easy matter for Lenoir, who was a friend of Beau de Rochas, to prepare one of his engines as a four-stroke engine. ("*On ne concoit pas que Lenoir ne l'ait tout au moins pas essayee ; cela n'exigeait pas qu'une bien faible modification dans les distributions de sa machine.*" "It is inconceivable that Lenoir did not at least try it; this would only have required a minor modification of his engine.")[11] Otto not only invented the four-stroke cycle at the same time as Beau de Rochas, but he also realised it practically at that time. "*Otto avait donc realise en* 1861 *ce que Beau de Rochas indiquait comme un desideratum theorique en* 1862" ("So Otto realised in 1861 what Beau de Rochas indicated in 1862 as a design desirable in theory").[12] Beau de Rochas's inventive idea was later totally forgotten. When in England the paper was searched for on the occasion of the litigation concerning Otto's patent, a copy, still unopened, was found in the Library of the British Museum.[13]

Cancellation of the Patent

The plea of nullity finally succeeded; in Germany and France the essential claims of the Otto patent were cancelled. The four-stroke cycle had been known to Otto for fifteen years. In 1875 he had traced back the realisation to certain ideas relating to the formation of mixture. During the suction stroke, charge should be effected in various layers of different inflammability; beginning at the piston with the remaining gases which were no longer explosive, then pure air, enriched by gas in conformity with the gas valve opening later than the air slide, and, where ignition took place, a reliably igniting gas-air mixture was present. Thus, in Otto's opinion, reliable ignition seemed compatible with smooth combustion. This hypothetic formation of the mixture had been placed at the head of the claims, but it had been rejected because it could not be proved, so that it was not patentable. The four-stroke claim was rejected by citing Beau de Rochas, whereas the High Court of the Reich explicitly repeated the already mentioned priority rejection concerning the Reithmann engine. In Great Britain, however, the Otto patent remained. Beau de Rochas's paper was not valued as prior publication, as it had remained unknown. Long experience had led the British Court to a less formal interpretation of the Patent Law.

Many a factory adopted the four-stroke cycle. Lenoir now built a four-stroke engine, too. Various unsuitable designs appeared and disappeared. But the experience gathered by the Gasmotoren-Fabrik Deutz and its licensees under the justified protection of the patents was not easy to overtake. The design created by Otto remained the pattern. Otto himself invented and tested magneto-electric ignition later on. This became the starting point for the electric ignition later developed by Robert Bosch. The British licensee Crossley, who had already built Otto's atmospheric engine, surpassed the production capacity of the Deutz works and built, earlier than Deutz, very progressive engines of high cylinder output. When Otto died in 1891 more than 30,000 engines were operating on his system. The cylinder output had been raised up to 100 h.p. and several cylinders could be united.

Conclusion

If the names of Barsanti, Beau de Rochas and Reithmann had not appeared in history, progress with the four-stroke engine would not have been delayed. The practical importance of Beau de Rochas's paper was that it contributed to the early cancellation of Otto's patent: "... *c'etait bien Otto qu'on copiait, mais on s'en defendait et on ne parlait que de Beau de Rochas*" ("It was Otto who was copied, but this was excused by speaking of Beau de Rochas").[14] N. A. Otto created the gas engine independently of Barsanti, Beau de Rochas and Reithmann, which fact is recognised also by Bruce: "Recognition of the technical sagacity of Beau de Rochas and the craftsmanship and tenacity of Christian Reithmann must not be allowed to detract from the work of Nikolaus August Otto, the great pioneer of the gas engine and virtual founder of the gas engine industry." The designation "Otto cycle," used in Great Britain even sooner than in his home country, honours him as an inventor and successful engineer.

The four-stroke engine has existed for more than seventy-five years. During this period its history has been exhaustively investigated. Historical writing ruthlessly seeking the truth will not deny respect to the works of talented inventors who remained without success. But the clearer the development is described, the more outstanding is Otto's deed. The dust has been swept away from ingenious drafts, but no inventor can be brought to life out of paper. Let us leave Otto in his place in technological history as the creator of the internal combustion engine.

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2 Articles of Association, March 31, 1864. Archives of the Works, A. Langen, N. A. Otto, 1894, page 152. British Patent No. 2098, 1863.
3 A detailed description of Barsanti's and Matteucci's work is contained in: A. Uccelli, Storia della tecnica dal medio evo ai nostri giorni, Milano, 1945, pages 384–387. In conformity herewith information recently was obtained from the S.A. J. Cockerill, that in their records no reference is made to Barsanti. Guldner's remark (Verbrennungsmotoren 1903) referring to a picture of the engine and reading "built in 1857 by Cockerill," therefore is not correct.
4 Dugald Clerk, "Gas, Petrol and Oil Engine," London, 1910, Vol. 1, page 20.
5 A. Langen, N. A. Otto, 1949, page 65.
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7 The Engineer, April 18, 1952, page 539; July 5, 1940, page 5.
8 The Engineer, July 5, 1940, page 5.
9 "Nouvelles Recherches sur les Conditions Pratiques de plus grande utilisation de la Chaleur et en General de la Force Motrice, avec application au chemin de fer et a la navigation," Paris, 1862.
10 French Patent No. 52,539, January 1, 1862. It consists of the document granting Beau de Rochas "without examination and guarantee" a patent on "Improvement in practical conditions for attaining greater utilisation of heat and in general, of motive power, with application to railways and to navigation." The specification consists only of pages 25 to 35 of the paper. No drawings are attached.
11 A. Vierendeel, "Esquisse d'une Histoire de la Technique, 1921, Vol. 2, page 251.
12 G. Richard, "Les Nouveaux Moteurs a Gaz, 1892," page 23.
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Marshalling Yard at Thornton Fife

It is announced by British Railways (Scottish Region) that work is to start shortly on the preliminary stages of a new marshalling yard at Thornton, Fife. This project, which will cost some three-quarters of a million pounds, will be part of the development work taking place in the Fife coalfields. Prior to the war coal from this area was largely shipped from the Firth of Forth ports, whereas now it is being sent increasingly to Glasgow and other places in the West of Scotland. Already major railway schemes have been inaugurated at Kelty and Oakley, and the projected marshalling yard at Thornton, near the new Rothes colliery, now being sunk, will expedite the flow of coal to all parts of the country.

Thornton is a focal point of the principal part of the Fife coalfields, and the main railway routes which converge from all directions. The existing yards deal with all kinds of traffic in or for the east of Fife, but the facilities are costly to operate and inadequate to meet the needs of the expanding coalfields. The new marshalling yard is to be sited to the west of the present sidings and to the north of the Dunfermline-Thornton Junction main line between a point near Cluny Bridge and the Kinglassie colliery branch line at Redford Junction.

With connecting lines to Rothes colliery the yard will have at the outset twenty sorting sidings, with capacity of sixty wagons each; six reception sidings; six secondary sorting sidings; and the necessary approach and departure roads and shunting necks. At a later date the number of sorting sidings will be increased to thirty-five. The new yard will be laid out for hump operation and in its construction some 340,000 cubic yards of material will have to be excavated and tipped and about 27 miles of track laid down. An enlarged and modernised signalbox will be required at Redford Junction and a new box at Cluny Bridge. The scheme, which is being developed in close liaison with the National Coal Board, will take about three years to complete.

American Application of the Ugine-Séjournet Extrusion Process

(By our American Correspondent)

Whilst the conventional extrusion process for producing non-ferrous tubes and solid shapes is now well established, it was the development of the Ugine-Séjournet process, using glass as a lubricant, which has recently allowed hot extrusion to be applied to the production of stainless steels and highly-alloyed refractory metals, on an economical basis. This article outlines the history of the process and the applications it is finding in the United States and describes in detail the extrusion installation at the Tubular Products Division of the Babcock and Wilcox Company in Beaver Falls, Pennsylvania.

THE production of steel bars, shapes and tubes by hot extrusion has been under investigation for a considerable time by the Acieries Electriques d'Ugine, in France, and tests conducted by this company as early as 1925 indicated that steel could be extruded under suitable conditions equally as well as many non-ferrous metals. Actual commercial operation, however, was not obtained owing to the rapid wear and seizing of tools which usually functioned satisfactorily for only one or part of one operation. In undertaking continued research in this field, the Ugine company had three objectives :—

(*a*) The production of unbalanced sections, both hollow and solid, of shapes ordinarily extruded from copper-base and aluminium-base alloys, often in complex forms that either cannot be rolled or would require complicated rolling equipment, e.g. tubing for the manufacture of hollow turbine blades.

(*b*) The conversion into desired shapes of steels and high-alloy materials which cannot be rolled at all, or can be rolled only with great difficulty and generally with very low yields.

(*c*) The production of sections and materials readily rollable, but required only in such small quantities that the cost of rolls and, in some cases, even the cost of roll changing, would not be justified by the small quantities involved.

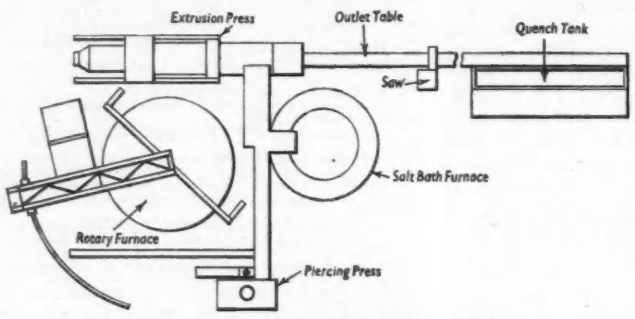


Fig. 1—Arrangement of Extrusion Installation

At the same time, the Comptoir Industriel D'Etirage et Profilage de Metaux (C.I.E.P.M.), a small private company engaged principally in the cold drawing of metals, was at work in Paris on the extrusion of non-ferrous metals and alloys, and had specialised in the production of unbalanced sections. In 1940, a technical agreement was signed between the two companies with a view to co-ordinating their efforts in the field of extrusion. The C.I.E.P.M. company approached the problem from the aspect of improved lubrication, but soon reached the conclusion that there was not one but two problems to be solved in this respect—the lubrication between the billet and the container and that between the billet and the die. Many lubricants were tried, and neither those that were solid at the operating temperatures nor those that were liquid gave satisfactory results. Furthermore, it was observed that under operating conditions materials containing carbon, instead of lubricating, appeared actually to promote seizing of the billet and the tools. It was decided, therefore, to experiment only with carbon-free materials and, more particularly, with materials melting at quite high temperatures.

These experiments led to the discovery that glass, introduced in solid form, was a most effective lubricant, and simultaneously served as an insulator to protect the tools from contact with the billet and with the section in the course of extrusion, and it also prevented the absorption of too much heat from the section. It was later realised that any similar substance possessing a sufficiently high softening point, an adequate viscosity at the operating temperature, and melting over a suitable range of temperature, would supply the necessary qualities.

The large number of extrusion tests undertaken with various kinds of glass and glass-like materials served to emphasise the important influence exerted by the viscosity and the diffusivity of the glass employed as well as its quality and quantity. Among the glasses successfully used, the following may be noted :—

	Glass No. 1	Glass No. 2	Glass No. 3
SiO_2, per cent	60	72	65
Al_2O_3, per cent	5	4	4
CaO, per cent	14	8	14
Na_2O, per cent	14	13	8
Other elements (total), per cent	7	5	9

Later work showed that the physical form of the glass could be altered advantageously ; hence, the original glass plate used against the die and the glass " test tube " used around the mandrel in the production of tubes have now been replaced by fibrous or woven glass of the simplest possible form.

Fig. 4—" Fibreglass " Sock on Extrusion Press Mandrel

American interest in the Ugine-Séjournet process led to contact being established between the C.I.E.P.M. company and the United States Steel Company in 1946, and finally resulted in the completion of a licence agreement and the installation of a steel extrusion plant at the Gary works of the company, which is expected to be in operation shortly.

The first agreement for the use of the Ugine-Séjournet process in the United States was made in June, 1950, when a licence was granted to the Babcock and Wilcox Company, embodying the specific use of glass as a lubricant and insulator in the extrusion process. It is this installation which is described in the paragraphs herewith.

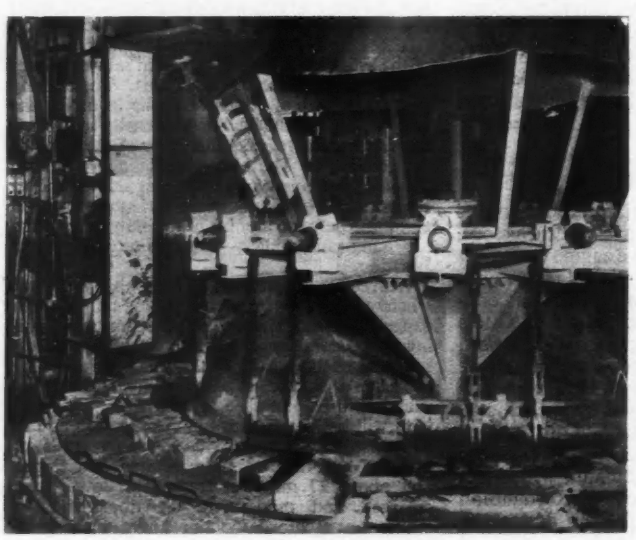


Fig. 2—Rotary Salt Bath Furnace

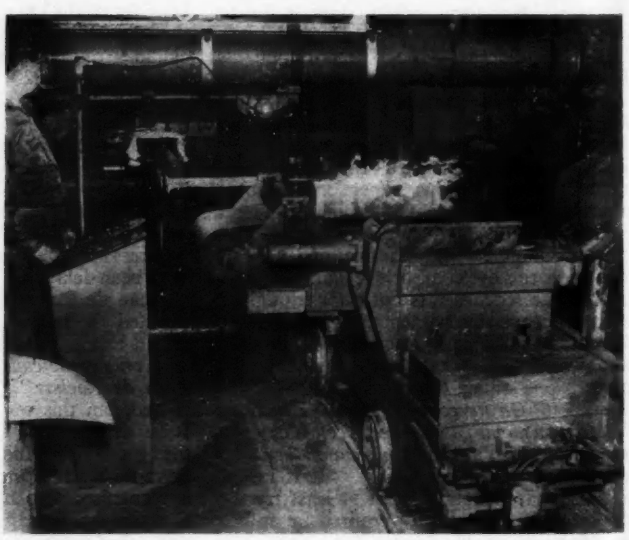


Fig. 3—Billet picking up Glass on Transfer Bogie

Another American licensee of the process, the International Nickel Company, changed over to the use of glass lubricants in the extrusion of nickel-rich alloys at its Huntington works early in 1951. In August, 1950, the Allegheny Ludlum Steel Corporation signed an agreement with the C.I.E.P.M. company, and a 1600-ton hydraulic press is now being installed at the Watervliet works of the company for the extrusion of alloy steel and titanium billets up to 7½in

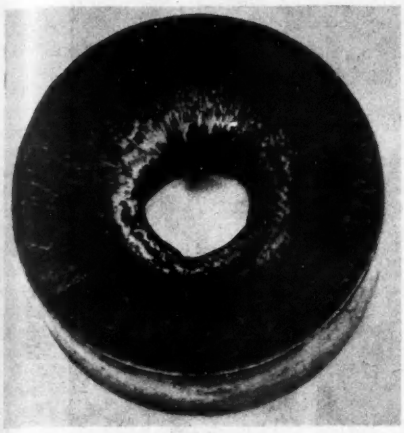


Fig. 5—Alloy Steel Die, Spoilt by the Use of Conventional Lubricant

diameter by 24in length. An installation at the Pittsburgh works of the Jones and Laughlin Steel Corporation is expected to be operating early in 1953.

Extrusion Procedure

The most significant discovery by the engineers of the C.I.E.P.M. company, and the one which had a major effect on the life of the extrusion die and the surface quality of the stock produced, was the substitution of glass for the carbonaceous materials previously used as a lubricant. The glass, melting on contact with the hot steel, prevents seizing of the billet and tools and insulates the tools from the heat of the billet. The

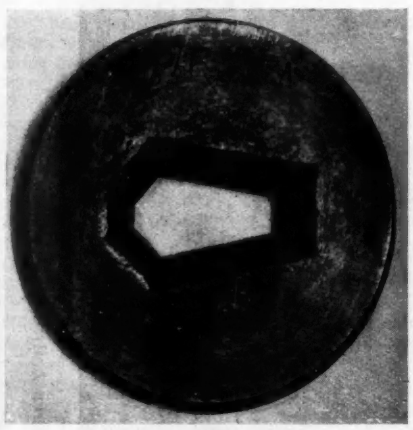


Fig. 6—Alloy Steel Die, Maintained by the Use of Glass Lubricant

lubricating properties of the glass reduce friction and have made it possible to increase the billet length.

In the extrusion of tubing, a hollow billet is confined in the container between the ram of the press and the die. Although it is possible to produce a hollow billet by forcing the extrusion mandrel through it prior to extrusion in the same press, this method has been found to have limitations with regard to mandrel strength and stiffness. An alternative method used by the C.I.E.P.M. company, and adopted by the Babcock and Wilcox Company, makes use of a separate vertical press for piercing. The benefits resulting from the use of a separate piercing press in this process are primarily concerned with the concentricity of the final tube, which, of course, depends on the concentricity of the pierced billet prior to extrusion.

The extrusion plant at the Beaver Falls works of the Babcock and Wilcox Company has been designed for the production of tubular or solid shapes, and the arrangement of the equipment is shown diagrammatically in Fig. 1. The billets are charged into a rotary hearth gas-fired furnace, After heating, if they are to be made into tubing, they are rolled across a "glass-pickup" table to the piercer charging device; if they are to be made into solids they by-pass the piercing operation and go directly to the salt-bath furnace. The piercing is done with glass interposed between the billet and the piercing mandrel and, depending on analysis, either with or without glass between the container and the billet. The pierced or unpierced billet is charged into a metal basket which supports it in a rotary salt-bath furnace (Fig. 2). A hook on the surface of a large drum lowers the basket on to a rotating support, and a cam surface on the drum advances the support and indexes the next basket into position where the hook will be able to lift it from the bath. At the conclusion of its circuit round the furnace, the basket is lifted out by the same drum and the billet is discharged into a trough mounted on a transfer bogie. This transfer bogie has an inclined surface on which a "Fibreglass" mat is placed. As the bogie travels toward the extrusion press, the billet is raised out of the trough and as it then rolls down the inclined plane it fuses to the "Fibreglass" mat and picks it up as shown in Fig. 3. By the time the transfer bogie reaches the end of its travel, the billet has rolled into a trough at the front end. This trough lines up with the container bore, and the billet is automatically pushed into the container. In the meantime, a "Fibreglass" "sock" has been slipped over the extrusion press mandrel (Fig. 4), and a glass cartridge placed against the die. With the mandrel lubricated by the "Fibreglass" "sock," the die, lubricated by the cartridge, and the container lubricated by the glass picked up by the billet in passing across the transfer bogie, metal to metal seizure is prevented on all surfaces. The extrusion operation is effected in from two to four seconds, yielding a piece from 20ft to 60ft long, depending on the size of billet and the area of extruded section. The tube can be cut into shorter lengths on a hot saw and either quenched or rolled on to a cooling bed, depending upon analysis.

With regard to extrusion die life, Figs. 5 and 6 are of interest. The former shows the result of one bar having been extruded through an alloy steel die, using a conventional lubricant. The bar was not usable, and the die was ruined. Fig. 6 shows a more complex die which is still in good surface condition after thirty-two bars of sound metal have been formed by it, with the use of glass lubricant. Finally, it should be mentioned that the movement of metal through the die when using glass or glass-like lubricants is such that the outer surface of the billet remains at the outer surface of the extruded object and that there is a regularity of movement of the metal during the operation. This is clearly illustrated by Fig. 7, which shows an extruded bar made from a billet of 18–8 stainless steel, into which had been fitted transversely a number of wires of tool steel having about the same deformation characteristics. Various portions of the extruded bar, after longitudinal sectioning, turning of the cut face and acid etching, illustrate the manner of movement of the metal.

Extrusion Equipment

The gas-fired rotary-hearth furnace used to bring tubing billets to piercing temperature and to bring solid billets to pre-heat temperature has a hearth diameter of 23ft and a heating capacity of 5 tons of steel per hour from room temperature to 2250 deg. Fah.

The 450-ton vertical piercing press, which has containers ranging up to 8in in diameter, has a stroke of 34in, which is sufficient to supply a 28in pierced billet to the extrusion press. After piercing, the container of the press can be shifted either under the piercing cylinder or out over a stripping cylinder where the pierced billet is pushed out and the next solid billet is received. The rotary salt-bath furnace used for reheating pierced billets and for completing the heating of solid billets has a heating capacity of 5 tons of steel per hour from 1600 deg. to 2250 deg. Fah. It is powered by six 150kW, three-phase transformers which are switched on and off by an automatic temperature control unit. The purpose of salt-bath heating is to provide the extrusion press with billets as nearly scale-free as possible.

The 2250-ton extrusion press also has containers to handle billets up to 8in in diameter. The unusually long stroke of the main ram is 100in, to allow a billet 28in long to be placed in front of the container before the start of the stroke. One aspect of the Ugine-Séjournet process is a very fast extrusion stroke, which minimises tool heating. The press is designed with a prefill speed of 21in per second and a possible power stroke speed of 6in per second. The unit operates at a pressure of 3600 lb per square inch; water is supplied from two air-water accumulators, one

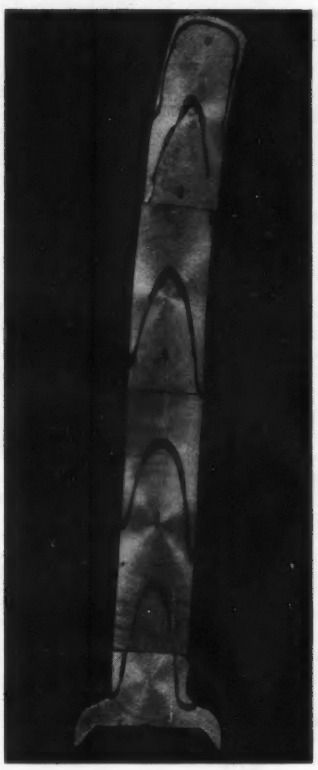


Fig. 7—Test Billet Indicating Flow of Metal in Extrusion

being for the supply of the main press cylinder, and the second for the supply of the extrusion press auxiliaries and the piercing press.

Operating Experience

The application of the Ugine-Séjournet extrusion process has opened a new horizon for the production of seamless tubing and solid shapes from the more refractory stainless steels and high melting-point alloyed metals. Whilst many of the more common austenitic and ferritic stainless steels can be produced by the conventional rotary piercing process, there are mechanical forces present in rotary piercing which prevent the piercing of the less plastic steels and metals. Through extrusion, a large and important range of unpierceable alloys, suitable for certain high-temperature uses with greatly improved creep properties and other alloys with greatly increased resistance to corrosion, have now become available as tubing. Numerous highly-alloyed steels not readily procurable in seamless tube form are now being made available by this new process, including such unbalanced composition stainless steels as 25 per cent Cr–12 per cent Ni steel; 25 per cent Cr–12 per cent Ni–0·8 per cent Cb steel; 25 per cent Cr–20 per cent Ni–2·5 per cent Mo steel; 17·5 per cent Cr–9 per cent Ni–2·5 per cent Mo steel; and 19 per cent Cr–10

CAMBRIDGE UNIVERSITY ENGINEERING DEPARTMENT

The New Building

Reading Room

Stress Analysis Laboratory

Metallurgical Department

per cent Ni–3 to 4 per cent Mo steel. The process has also proved adaptable for the extrusion of high carbon, 17 per cent Cr–0·75 per cent Mo stainless bearing steels, and of several free-machining stainless steels which could not be pierced successfully by the rotary piercing method. It may also be applied to the extrusion of tool steels, gas turbine "super alloys," molybdenum, vanadium, titanium and zirconium. Where necessary, these materials can be further processed after hot extrusion although in most cases some modification of regular finishing practices will have to be instituted in keeping with the characteristics of each particular material.

With regard to highly-alloyed materials, tubular extrusion enjoys a considerable economic advantage over rotary piercing, particularly wherever cold reduction takes place subsequent to the production of a hot-finished tube. The advantage in this case is the ability of the extrusion process to : (1) produce a tube free from breaks in the surfaces ; (2) produce smaller, lighter-walled tubes than is possible by rotary piercing ; and (3) produce high-alloy tubes at a faster rate per man-hour than is possible by rotary piercing. The extruded surfaces which have already been produced have required almost no grinding on the outside surface, and the internal surface has been so good that no finishing work was required to be done. This has resulted in a reduction of more than 50 per cent in the amount of work and material which had previously been lost in grinding out surface defects. It is expected that the surface finish will show still further improvement in the future.

The ability to produce a small light-wall tube by extrusion also eliminates an appreciable amount of cold work. Whilst leaving a sufficient number of passes to assure the surface and mechanical characteristics of a cold-worked tube, the pattern of sizes is such that roughly half the cold-work passes may be eliminated by producing tubing by extrusion. Thus, both the saving in passes and the reduction in conditioning time will have an impact on the in-process time, with resultant savings in production costs. For stainless steels, it has been found that production per man-hour by the extrusion method actually exceeds that of a rotary piercing mill, rolling mill and reeler installation with a rotary furnace, producing a similar range of sizes. Although less pieces per hour are produced on the extrusion press, the weight per piece is far greater than that produced on a rotary piercing mill. It is estimated that the production per man-hour by extruding is 30 per cent greater than that obtained by rotary piercing.

To the high-alloy steel business with its comparatively small orders, flexibility of production is another important advantage offered by the extrusion process. A change in size on the extrusion press requires only changing of the mandrel and the insertion of a different size die, and it is stated that less than four minutes are generally required to make this change. However, in the case of carbon steel and low-alloy steel grades, the output in pieces per hour obtainable from the rotary piercing mill is so high that it is considered doubtful if the extrusion method would ever be able to compete with it.

Cambridge University Engineering Department

On Thursday of last week the new wing of the Department of Engineering in the University of Cambridge was opened by H.R.H. The Duke of Edinburgh. This is the first major building to be completed in the University since the war, and has added 53,000 square feet of floor space to the existing accommodation of the Engineering Department.

ALTHOUGH interest in engineering education in the University of Cambridge can be traced back to the appointment of Robert Willis, an "expert in mechanisms," as Jacksonian Professor in 1857, the real history of the engineering department began in 1875, when James Stuart was appointed first Professor of Mechanism and Applied Mechanics. But the development and progress of the engineering school took greater significance on the appointment, in 1890, of the late Sir J. Alfred Ewing, F.R.S. Almost at once, Sir Alfred succeeded in promoting engineering to the dignity of a Tripos course and the first Tripos examination in mechanical sciences was held in 1894. When Sir Alfred left Cambridge to join the Admiralty in 1903, the number of students reading engineering had risen to over 200. Professor Bertram Hopkinson followed Sir Alfred Ewing as head of the department, and until the time of the first world war, the number of engineering students continued at about the 250 mark. During that war, Professor Hopkinson met his death in a flying accident, and he was succeeded, in 1919, by the late Professor Sir Charles Inglis. In the years following the first world war, there was a rapid increase in the number of engineering students, and by 1920 it had reached a total of 808. There was, however, some decline in the immediately succeeding years, and the number of students became stabilised at about 550.

Originally, the engineering department of Cambridge University was housed in laboratories in Free School Lane, but the accommodation which they provided was being taxed to the utmost by 1914. With the overwhelming entry of students after the first world war, it was essential to move the department to an entirely new area, and the Scoope House site, in Trumpington Street, consisting of a Regency house and four acres of garden, was acquired. There, between 1920 and 1923, a single-storey laboratory building, covering about 50,000 square feet, was erected and equipped at a cost of approximately £100,000. The existing Scoope House was retained for office and administration purposes, the new building housing the main teaching laboratories, i.e. heat engines, hydraulics, structures, materials and electricity. As a Chair of Aeronautical Engineering had been added to the department in 1919, an aeronautics laboratory was set up in some temporary hut buildings. An article describing in detail these developments which followed the first world war was published in THE ENGINEER on October 24, 1924. Later, in 1931, a two-storey building was erected which provided, on the ground floor, two lecture theatres, each capable of accommodating nearly 300 students, and on the upper floor a drawing office, 125ft long by 40ft wide.

Recent Developments

During the first world war, the engineering department of Cambridge University was practically denuded of students. The conditions which prevailed during the second world war were very different. For nearly the whole period of that war, the department was kept busy training cadets for the services and engineers required in various branches of war-time industry. Sir Charles Inglis retired from his position as head of the department in 1943, and Professor J. F. Baker succeeded him. Simultaneously, despite the demands made by the critical stages of the war, planning for the future development of the department was begun. It was envisaged that there would be a moderate increase in the number of undergraduates and a considerable increase in research and post-graduate work brought about by the rapid advances in engineering practice and by the progress of engineering educational methods. The first step taken in the post-war programme was the erection of a two-storey workshop and instrument shop building, covering an area of 20,000 square feet. The previously scattered sections of the workshops—including the smithy, welding shop and carpenter's shop—were brought together into that building, and many additional machines were acquired. There were thus provided fully-equipped workshops, capable of meeting the demands of the engineering department—and all other laboratories in the University—for teaching and research equipment. This workshop was opened in 1949 by the late Field-Marshal Smuts, who was then Chancellor of the University.

The second stage of the post-war development programme was the erection of the five-storey building which was officially opened last Thursday week by H.R.H. The Duke of Edinburgh. This building, which has added 53,000 square feet of floor space to the accommodation of the engineering department, is 237ft long, 39ft wide and 70ft high. It is a steel-framed structure, the external walls being of Buckinghamshire brick, with Portland stone dressings and projecting cornice. In the design of the building, the aim of dignified simplicity has certainly been achieved, and the large windows provide excellent lighting for the large rooms within. The architects were Messrs. Easton and Robertson, 53, Bedford Square, London, W.C.1, the consulting engineers were Messrs. R. T. James and Partners, 6A, Lower Grosvenor Place, London, S.W.1, and the main contractors for the building were Messrs. William Sindall, Cambridge. The photographs which are reproduced on the opposite page—by courtesy of the architects and the photographers, Ramsey and Muspratt, of Cambridge—give an excellent impression of the exterior of the new building and of some of the departments which it houses.

The accommodation is arranged on five floors above ground and in a basement below. On the top floor there are a caretaker's flat and several studies for research students—of whom fifty are working in the department at present—together with a dark room, a drawing office, and a computation laboratory devoted to their use. On this floor also, and on lower floors, there are research laboratories for thermodynamics, aeronautics, electricity, soil mechanics, servo-mechanisms, materials and structures, and a constant temperature room. The fourth floor is devoted to studies and private laboratories for the fifty-three members of the teaching staff of the department, and on the third floor there are a large committee room, common rooms for the teaching staff and research students, and more laboratories. The second floor, which is devoted almost exclusively to undergraduate activities, contains three lecture rooms and a library which has capacity for 14,000 volumes and 120 periodicals. There is also a reading room providing comfortable accommodation for thirty readers. The first floor consists of the professors' rooms and administrative offices, and on the ground floor there are the structures research laboratory and a large lecture room, in addition to the imposing entrance foyer and the porter's lodge. The cloakrooms are housed in the basement, which also accommodates the boiler plant serving the whole site, heating being by low-pressure hot water circulated to radiators. All the rooms are well ventilated, and the building is served by a fully-automatic lift, which will take fifteen passengers or carry 1 ton of goods. Future additions to the new building will eventually extend the laboratory space for heavy equipment, make provision for an aeronautics wing and a large lecture theatre seating over 400, and give extra space for research workers.

At the opening ceremony, H.R.H. The Duke of Edinburgh was received by the Lord Lieutenant of Cambridgeshire, Captain R. G. Briscoe, the Mayor of Cambridge, the Chancellor of the University, Marshal of the Royal Air Force, Lord Tedder, and other dignitaries. Prior to the opening of the new building the honorary degree of Doctor of Law was conferred upon His Royal Highness at Senate House. Speaking in the engineering department, the Duke of Edinburgh said that it was essential in such a school that the teacher should remain an engineer. The simplest way for him to do so was to engage in applied research which would bring him into contact with industry. There were many different ways, the Duke continued, in which industry could be helped artificially, but if it was to compete successfully on level terms with the rest of the world, then our

scientists and engineers must be just that little bit better than any others. That, His Royal Highness suggested, could certainly be achieved if the system of teaching was good enough and if it could properly anticipate the country's needs. The solution to the country's industrial problem was to be found in the universities and technical colleges.

Teaching

Developments in the engineering department at Cambridge since the war have not been—as the University itself says—wholly in terms of bricks and mortar. In 1945, a Chair of Electrical Engineering was established with the help of the Institution of Electrical Engineers, and to it Professor E. B. Moullin was appointed. In 1948, an appeal was launched for funds to provide, among other needs, a permanent endowment for that Chair and for a Chair of Applied Thermodynamics and other departmental necessities. The appeal evoked a generous response, BEAMA providing the endowment for the Chair of Electrical Engineering, and Imperial Chemical Industries, Ltd., that for the Chair of Applied Thermodynamics, which was established last year. To the latter, Professor Hawthorne was appointed.

The engineering department at Cambridge has, for many years now, held a high place among the undergraduate teaching schools of the world. At present, 661 students are accommodated, the majority of them following the three years honours course leading to Part I of the Mechanical Sciences Tripos. This is a general course in engineering science and allows of no specialisation. Exceptionally well-equipped men can complete the Part I course in two years and study in their third year for the Mechanical Sciences Tripos, Part II. While this is still confined mainly to fundamentals, specialisation is allowed so that the men, by narrowing the front on which they work, can learn to go deeper. The students are divided into four groups. In group A the specialisation can be in structures or hydraulics and soil mechanics; in group B, in thermodynamics or mechanics of machines: in group C, in aeronautics, and in group D, in several branches of electrical engineering. In addition to the honours course a pass degree course is provided. It has a less mathematical bias but, like Part I of the Tripos, it is a full three year course on which the Engineering Institutions allow exemptions from their examinations.

Research

In the organisation of the research work undertaken in the engineering department at Cambridge three essential functions are kept in mind. The first is that the undergraduates should be taught by engineers. One difficulty facing the teacher living in an academic atmosphere is to maintain his lively interest and experience as an engineer. A satisfactory way of overcoming that difficulty is by engaging in applied research on a subject of interest to industry. The second function is to train research students. British industry is now well aware of the need to set up research organisations and there is a steady demand for applied scientists to staff them. At Cambridge, the engineering department does not encourage men to remain at the University to follow a course of research immediately after their undergraduate studies, but it welcomes those who wish to return after two or three years spent in industry. At the present time fifty graduates of its own and other universities are working in the department for higher degrees. The third function is the search for new knowledge which is, of course, bound up with the other two. While industrial organisations can often provide much finer equipment than that found in a university, the university still provides the best atmosphere in which to carry out original scientific work. There are many projects peculiarly suited to university laboratories, particularly long-term fundamental work which does not show early promise of profitable results. There are also occasionally, even to-day, investigations which industry may not wish to have carried out and which can only be followed, to the ultimate benefit of the community, in a university laboratory.

The investigations being carried out at Cambridge cover almost every aspect of engineering. In aeronautics, under Sir Melvill Jones, who occupied the Chair of Aeronautical Engineering from 1919 to earlier this year, when he was succeeded by Professor Mair, much emphasis has been placed on experiments in flight, and a study of the influence of distributed suction on the boundary layers of wings has recently been made. In the electrical laboratory, the eddy current anomaly in commercial grades of electrical sheet steel has been investigated, work has been carried out on the electron trajectory tracer, and an electrostatic electron microscope has been constructed and converted to a scanning microscope. Work is also in hand on semi-conductors and on electron bombardment conductivity in insulating crystals, amongst other problems.

In the heat engines laboratory, where Sir Frank Whittle carried out his early work leading to the development of the gas turbine, several problems in that field are still under investigation. Other work is on liquid metals, the phenomenon of "blow-by" in high-speed internal combustion engines, the combustion of liquid fuels and the scavenging process in two-stroke engines. In hydraulics, the investigations range from the swirling flow of water through a nozzle to the development of an open water channel with a high-degree of uniformity both in depth and velocity for testing ship models, and include work on the action of the centrifugal pump. The materials laboratory has been engaged for some years on an important investigation of the brittle fracture of steel, a problem brought into prominence by the cracking of "Liberty" ships during and after the war. The dynamic properties of metals have also been investigated and work has recently begun in a new cement and concrete laboratory. The department is active in the field of stress analysis, one of the most important investigations in the photo-elastic field being on the dynamic stresses in gear teeth. An up-to-date soil mechanics laboratory has been set up in the new block, and one investigation recently completed was on the mechanical behaviour of tillage implements in field soil.

Cambridge has always taken a leading part in research on structures. For many years, an investigation into the true load-carrying capacity of rigidly jointed steel-framed structures has been carried out. This has enabled an entirely new approach to the design of structures to be made, based on the plastic behaviour before collapse. The method can now be applied to several kinds of structure, notably the single-storey factory building, several of which have been erected showing a saving in weight of steel of 25 to 30 per cent over orthodox designs. Much work on instability of compression members and beams in steel and light alloys is also in hand, and a considerable research, carried out in co-operation with the Admiralty, on the stresses in ships' structures has recently been completed.

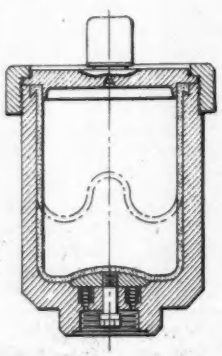
Post-Graduate Instruction

While the results of research are freely published, it has been not uncommon in the past for thirty to forty years to elapse before some new and important development was generally accepted. This is partly due to the difficulty the engineer, busy with his industrial duties, has in keeping up-to-date by reading, but also to the very complexity of applied research. Such delay is a most serious matter in this country to-day. One way to combat it is to give experienced engineers further formal instruction. The University Grants Committee has, in recent years, made it possible for those university engineering departments which had specialist knowledge, gained usually by their own researches, to organise courses of instruction to which engineers from industry could be admitted. The great effort made by the Cambridge University engineering department in structural research, leading to a successful new approach to structural design, and its interests in welding and welded structures enabled it to organise such a post-graduate course on the subject of "Theory of Structures and Strength of Materials." The first course, of nine months' duration, which began in October, 1951, was attended by six engineers returning from industry. The second course, which started last month, is being attended by nine men. The interest which industry generally is taking in these courses is shown by the fact that all but one of these students have been sent to Cambridge and supported by their firms.

Pneumatic - Hydraulic Closing Mechanism for Circuit Breakers

A RECENT visit to the Loughborough works of the Brush Electrical Engineering Company, Ltd., gave us an opportunity of seeing a novel form of circuit-breaker closing mechanism, based on the energy stored in a quantity of air at high compression. In this mechanism, circuit breaker closure is effected by a hydraulic piston, the fluid pressure being derived from a pneumatic accumulator of a kind which has been used for many years for the impulse starting of heavy compression-ignition engines.

The main elements of the mechanism are shown in the accompanying drawings. From the first of these illustrations it will be seen that the accumulator consists of a small steel cylinder containing a "Neoprene" diaphragm. The diaphragm and the lid of the cylinder form a sealed container which can be charged with air at 2000 lb per square inch through a valve in the lid. The cylinder diaphragm being sealed, no recharging with air is required. Oil is then pumped into the lower part of the cylinder body until the air on the opposite side of the diaphragm is compressed to about 4000 lb per square inch, when the diaphragm takes up the form indicated by the dotted lines. At 4000 lb per square inch, the stored energy in the system is enough for four successive closing operations of the circuit breaker contacts without repumping oil.

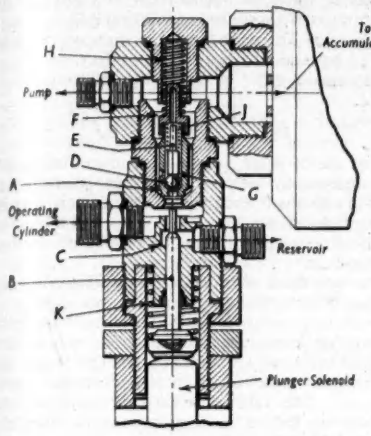


Sectional View of Accumulator

Release of this stored energy for the closing operation by hydraulic means is effected by a solenoid-operated two-way valve, details of which are shown in our second drawing. When the valve is in the de-energised position, as in the drawing, oil is stored under pressure in the accumulator, in the pipeline to the pump, and up to the main valve seating *A*. When the valve solenoid is energised, the rod *B* is raised by the solenoid plunger and, during its initial movement, the large-diameter portion enters the orifice *C* to seal the circuit breaker operating cylinder from the oil reservoir. Further movement of the rod *B* causes the reduced-diameter part to lift the ball valve *D*, and thus allow a restricted flow of oil to the operating cylinder, to take up any slack in the contact operating mechanism. Continued movement of the rod *B* causes the ball valve rod *E* to butt against the facing *F*, thereby lifting the whole of the main valve assembly *G*; unrestricted flow of oil is accord-

ingly established between the accumulator and the operating cylinder, and the full working pressure of 4000 lb per square inch is made available.

When the valve solenoid is de-energised, the sequence of events is reversed; the main valve is first seated by the spring *H*, the ball valve is then seated by the spring *J* and, finally, the rod *B* is withdrawn from the hole *A* by pressure from the spring *K*. The oil in the operating



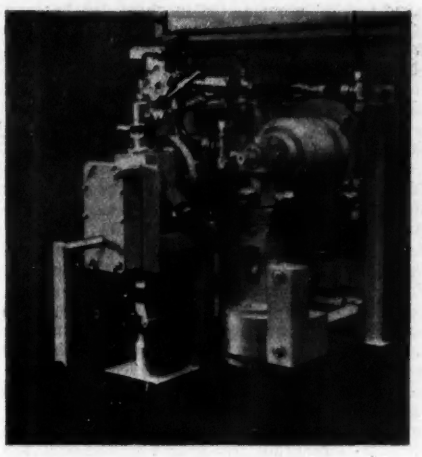
Solenoid-Operated Valve

cylinder can, thereby, return to the reservoir the necessary pressure being derived from a spring behind the operating piston.

A sealing switch, actuated by the solenoid plunger ensures that, once the valve solenoid is energised, it remains so until the circuit breaker has completed its closing stroke.

Oil is pumped from the reservoir to the accumulator by a standard fuel injection unit of the kind used on compression-ignition engines. The pump is driven by a single-phase, ¼ h.p. capacitor start induction motor under the control of a pressure switch, which starts the motor after a fall in pressure in the accumulator and stops the motor when the pressure is restored. Normally the pressure switch disconnects the motor at a predetermined accumulator pressure (about 4200 lb per square inch). As a further precaution there is, on the high-pressure side of the pump, a relief valve, which opens under

33kV Circuit Breaker fitted with Pneumatic-Hydraulic Mechanism



Pneumatic-Hydraulic Operating Mechanism for Circuit Breakers

excess pressure (about 4500 lb per square inch) to by-pass the oil back to the reservoir.

The pressure switches are operated from a plunger type of pressure gauge. Apart from the control of the pump motor by pressure switches, there is a cut-out switch to interrupt the control valve solenoid circuit and prevent operation of the closing mechanism if the accumulated pressure is too low for satisfactory closing.

The close-up view of the mechansim reproduced herewith shows, on the left, the motor-operated pump, and, below it, the pressure-switch assembly with the cover removed. The pressure gauge element carries a pointer moving over an indicator having an upper zone, painted red, to indicate excess pressure, a central zone, painted white to indicate normal pressure, and a lower zone, painted green to indicate inadequate pressure. The pointer and indicator can be seen through a rectangular window in the cover of the switch assembly. On the right of the photograph there are the accumulator, the valve and, below them the operating solenoid.

In an emergency, such as a solenoid fault or supply failure, the control valve can be hand-operated at normal speed by making use of a detachable lever which is shown in position in the photograph referred to above. There is also a detachable crank handle, which can be fitted to the pump shaft, as shown, to allow hand-charging of the accumulator oil in an emergency. It should be appreciated, however, that sufficient fluid is stored in the accumulator, when it is charged at 4000 lb per square inch, for four successive closing operations without recharging. Four such operations, without recharging, would lower the pressure from 4000 lb per square inch to about 3200 lb per square inch. The solenoid-operated valve may be energised from a 30V, 10A-h tripping battery and four circuit breaker closing operations can be executed without recourse to local a.c. supplies.

On our visit to the manufacturer's works we saw a demonstration of the "PH" closing mechanism, fitted to a Brush "OR 38" oil circuit breaker, rated at 33kV, 1000A, 750MVA, as illustrated herewith. The demonstration programme began with normal closing operation of the mechanism, and tripping, the accumulator being recharged to normal pressure. Then with normal motor charging of the accumulator, a "close-open-close-open" operation was performed in rapid sequence. Next it was shown that, with the charging motor deliberately cut out, four "close-open" operations could be performed before the low pressure cut-out operated. Later, with the maximum-pressure switch short-circuited, the pump motor was allowed to run to demonstrate the operation of the by-pass safety valve, which limits the maximum pressure attainable to about 4500 lb per square inch. Another property demonstrated was that three or more closing operations could be carried out using the emergency closing lever without the use of any electrical supply.

Utilisation of Solar Energy

The following abstracts are taken from the report of a National Physical Laboratory committee set up to consider the possibilities of using solar energy, and to advise whether any programme of research should be undertaken or sponsored by the Department of Scientific and Industrial Research. The committee concerned itself only with fairly direct applications of solar energy and not with such sources as wind power which are only indirectly related to the sun.*

THE subject has a large literature (e.g. F. A. Brooks[1], H. C. Hottel[2] and C. B. Abbot[3]) which records many small-scale projects, but so far as we are aware, solar energy is nowhere used on any considerable scale for heating or for the production of power.

We have proceeded by considering the various purposes for which heat and power are required and determining what are the limiting factors in applying solar energy. We have not entered into the details of design, and have assumed that purely engineering problems can be solved, so long as there is no conflict with natural laws. When in doubt we have taken an optimistic view, but even so, our conclusions are not encouraging. It seems unlikely that solar energy can be an important source of heat or power in the near future, though some applications may be possible in specially favourable circumstances. In particular, it is possible that the availability of very modest amounts of power would have important and beneficial effects on the economy of tropical agricultural areas.

Available Energy

The amount of heat arriving from the sun at the outside of the earth's atmosphere varies only slightly, and is, on the average, 1·35kW/m². The amount of energy reaching the ground near sea level depends on the sun's altitude, the cloudiness and the state of the atmosphere. The maximum of direct radiation on a surface normal to the sun's rays on very clear days reaches 83 per cent of the incident energy (1·12kW/m²) at Ouargla, in Algeria. At Kew, it is 70 per cent (0·94kW/m²); other stations give values between these.[4,5] However, these maxima are rarely attained and are only useful in estimating the maximum capacity of the plant necessary to make full use of the available energy.

The average amount of energy received has been conveniently summarised by H. H. Kimball[6] who gives curves showing its distribution over the surface of the earth. The curves cover the sea areas only, but can probably be applied to the land without serious error. For the present purpose, the variation with longitude can be neglected and the results summarised as in Table I. The figures are Kimball's figures for 20 deg. W longitude for a day of twenty-four hours, and include both direct and diffuse radiation. The averages for the whole year are the

TABLE I—*Energy Received on a Horizontal Surface (kW/m²)*

Lat.	On clear day		On day with av. cloudiness		
	June	Dec.	June	Dec.	Year
60 deg. N	0·38	0·03	0·19	0·01	0·10
40	0·37	0·13	0·22	0·07	0·15
20	0·34	0·22	0·22	0·15	0·21
0	0·29	0·31	0·15	0·19	0·19
20	0·22	0·37	0·13	0·23	0·19
40	0·11	0·42	0·06	0·28	0·17
60 deg. S	0·02	0·43	0·01	0·16	0·08

* The committee consisted of Dr. E. C. Bullard, F.R.S. (chairman), Professor P. M. S. Blackett, F.R.S., Professor F. G. Gregory, F.R.S., Professor E. A. Guggenheim, F.R.S., Professor W. R. Hawthorne, Dr. H. Heywood, Professor Willis Jackson, Professor F. E. Simon, F.R.S., R. Edmonds (secretary).

means of Kimball's figures for March 21st, June 21st, September 21st and December 21st. It is remarkable that the total radiation received per day in England in the summer is greater than that received in India. This is due to the greater length of the summer day in England, as was first pointed out by E. Halley[7].

The figures in Table I make no allowance for absorption by smoke and must be reduced by a factor, which may be as great as two, if the energy at a point in a large town is required. The figures refer to a horizontal surface. When the sun is low a substantial advantage is gained by tilting the collector. This would be an important factor in a place in a moderate or high latitude, with a high proportion of clear days in the winter. In England, the winter climate is so overcast that this factor is not of much importance. Tilting the collector does not, of course, alter the area of ground required to collect a given amount of energy, but it does reduce the actual area of collector.

From the above figures it is clear that though the rate of receipt of energy may reach 1kW/m², it cannot be expected in most places to average more than 0·1 to 0·2kW/m². It will, of course, be zero for more than half the time. The use that can be made of this energy will now be considered.

Heating

Brooks[1] showed that in California, a heater 6·6 square metres in area will provide domestic hot water for 270 days in the year, but that additional heating is required on the other ninety-five days. H. Heywood[8] states that in England 50 litres of water can be heated to 55 deg. Cent. for each square metre of receiving area on two-thirds of the days in the best five months of the year. This is equivalent to 0·097kW/m² on these favourable days. Hottel and Woertz obtained 0·052kW/m² during April to July, 1940, at Cambridge, Massachusetts[9].

Solar water heaters have been on the market in the United States for many years, but are used only on a limited scale. It seems unlikely that a campaign to encourage the sale of such heaters would result in a large enough saving of fuel to justify the capital cost. There is no prospect of substantial improvement of existing equipment by research and development.

House Heating.—Very similar considerations apply to house heating. In the tropics there is little demand. In temperate latitudes least heat is available when it is most wanted. Table I, with an efficiency of collection of 60 per cent, suggests that at 40 deg. N a collector with an area of 24 square metres would be required to collect 1 kilowatt in December. Trials in Boston, Mass., have shown that a collector whose area is half the floor area of the house can provide most of the heating required, but that some extra heat must be provided in cloudy spells during the winter.

In view of these considerations, we do not think that any action is necessary to improve solar heaters for domestic heating. We would, however, draw attention to the simplest method of using solar heat for warming houses—that is to let it in through the windows. In the past little attention has been paid to this in the design of houses, though substantial economies of fuel can be obtained on favourable sites by providing larger windows than usual and double-glazing them.

Cooking

In some places the only practicable fuel is cow dung, which would be better employed in fertilising the land.

It might well be feasible to construct a solar stove which could satisfy part of the needs of the inhabitants of India, whose main meal is cooked at midday, and generally consists of boiled rice or some kind of lentils. By designing a stove with suitable insulation to prevent excessive heat losses, it should be possible to reach and maintain temperatures of boiling water with 100 watts; this heat could be collected by a mirror of about 0·3 square metre.

A stove using a mirror and a pressure cooker has been built by the Indian National Physical Laboratory. There is no doubt that it is technically possible to cook food in this way, but it is not certain that the machine can be built at a price which an Indian villager can pay. We recommend that a contract be considered by the National Research Development Corporation for the design of a stove which would be suitable for large-scale production.

Refrigeration

It seems impracticable to use solar energy directly as the sole source of power for a domestic refrigerator for preserving food, since its operation must be continuous.

The use of solar energy for air conditioning is more attractive, as it is not essential that the system run continuously. There are well-known refrigeration cycles in which heat is pumped out at the cold end and absorbed into the machine at the hot end, so it would not be necessary to convert the heat into mechanical energy. It is difficult to estimate the amount of heat required without detailed consideration of a design.

As a rough indication, the cooling load for a building measuring 20m by 20m by 10m high may be taken as 40kW maximum load. An ammonia absorption machine may be assumed to have a coefficient of performance of 0·5 (ratio of cold produced to heat put in), so that the maximum heat input required would be 80kW. The incident radiation at noon during the hot weather in, say, India can be taken as 0·8kW/m² on a surface maintained normal to the sun's rays (this figure is higher than those in Table I which are twenty-four hour means). If the rate of heat collection is assessed at 0·4kW/m², a collector surface of 200 square metres would be required. This is half of the roof area, so that if the building were suitably orientated the incident solar energy would be sufficient to provide the requisite cooling effect. The lithium bromide-water vapour process, which has a coefficient of performance of 0·7, would require a correspondingly smaller proportion of collector surface.

Power

Owing to the intermittency of the supply, the direct use of solar energy for driving engines need not be considered for large power plants. There is, however, a number of purposes for which intermittent power as low as 1kW would be useful. In particular, the economy of the Indian village might be profoundly affected by the availability of such prime movers for water pumping.

As a basis of calculation, we assume that 1kW of power is required during the hot weather in India. The optimum temperature for running a small steam, vapour, or hot air engine would probably be about 200 deg. Cent.[3] A temperature higher than this would reduce the efficiency of collection and a lower temperature would reduce the efficiency of the engine. The efficiency of collection at such a temperature would not exceed 50 per cent and to attain this figure at 200 deg. Cent., a mirror collector would be required. The limit of efficiency set by the laws of thermodynamics for an engine working between 20 deg. and 200 deg. Cent. would be 38 per cent. Mechanical and irreversible thermal losses would reduce this to about 14 per cent. With these efficiencies (Table II) an average of 0·056kW of useful power per square metre during the part of the day when the sun was shining brightly would be obtained. For a power of 1kW, the area required would be 18 square metres. The efficiencies assumed are somewhat optimistic, but even so the area of mirror required is so large as to make the scheme too expensive for use in peasant agriculture. This conclusion might be modified if a suitable flat-plate collector could be developed though it would then be necessary to work at a lower temperature with a corresponding loss in engine efficiency and increase in area.

Table II—*Production of Power*

	per cent	kW/m²
Solar constant	100	1·3
At earth's surface (average for bright sunlight in tropics)	62	0·80
Heat collected	31	0·40
Converted to mechanical energy	4·3	0·056

The pumping of water from bores requires more power than the pumping of water from canals or rivers. The average connected load for over 2000 State-operated wells in the United Provinces is 10kW per well, and this load is used to about 40 per cent of capacity.[10] The use of solar engines to supply this would require impracticably large collectors.

We are thus regretfully forced to the conclusion that orthodox heat engines driven directly by solar power are not an immediate practicable proposition. We have also considered the possibilities of the direct generation of electricity by solar power without first converting it to mechanical energy. There are three known ways of doing this; by the thermo-electric effect,[11,12] by a photovoltaic cell[13] and by the photo-galvanic effect.

Production of Fuel

The use of solar energy to produce fuel which is subsequently used in an engine is attractive, as it avoids the consequences of the intermittency of sunlight and allows the energy to be used in applications requiring the continuous production of power.

Use of Plants to Produce Fuel.—The efficiency of the utilisation of sunlight by growing plants is remarkable. *Eucalyptus globulus* in India gives 2·4 kilogrammes of wood per year per square metre (9·4 tons per acre year). The wood has a calorific value of $2·1 \times 10^4$ joules/gm (5000 cal/gm.) The rate of storage of energy in the wood of an Indian eucalyptus forest is, therefore, 1·6 W/m² or 0·8 per cent of the energy reaching the ground. The yield from annual plants is of the same order. For example, H. A. Spoehr[14] states that the annual yield of sugar cane is 3·8kg/m² (15 tons per acre). With a calorific value of $1·7 \times 10^4$ joules/gm (4000 cal/gm) this would give 2 W/m².

If the wood of a eucalyptus forest is burnt and used in a steam engine with a boiler efficiency of 70 per cent and an engine efficiency of 14 per cent (this is higher than has yet been achieved in small commercial engines, which give about 5 per cent), it would yield 0·15 W/m² of forest. The alternative of fermenting vegetable matter to alcohol and using this in an internal combustion engine yields less power in consequence of the small proportion of the plant that can be converted to alcohol. For example, according to Spoehr, a kilogramme of sugar cane yields only 60gm alcohol.[14] With a calorific value of $3·1 \times 10^4$ joules/gm (7400 cal/gm) this would give 1860 joules per gramme of sugar cane, or 0·22 W/m². With an engine efficiency of 30 per cent, the useful power obtained would be 0·07 W/m². It seems unlikely that it would be worth while growing plants for fermentation, though in favourable circumstances the use of waste material may be profitable.

An estimate can be made of the possibilities of the wood-fired steam engine for irrigation. If it is assumed that the land to be irrigated requires, during the year, the equivalent of 0·5m of water to be raised from a depth of 10m, it can be shown, using the figures given above for yield, calorific value and efficiency, that the amount of land required for growing fuel for the engine is about one-fiftieth of the area to be irrigated. The value assumed for yield is what would be obtained under good conditions and is substantially greater than would be expected from peasant holdings. Even if a factor of 5 is allowed on account of optimistic assumptions, the project still seems practicable.

A significant comparison is with the bullock which is the commonest method of obtaining power on small holdings in India. An Indian bullock has been known to exert a force of 0·16 tonnes at 1·6km/hr for 8 hours. For this period, the bullock was producing 0·72kW. The average performance of bullocks in good condition is probably a third of this. The average for a twenty-four hour day is, therefore, 80W. The mean of five summer rations for Indian bullocks, suggested by P. E. Lander,[15] is 12kg per day (dry weight, 7kg per day). The winter rations are larger (30kg per day for the one example given), but the dry weight of 8kg is not very different. With a calorific value of $1·7 \times 10^4$ joules/gm (4000 cal/gm), the bullock is consuming food, which, if burnt, would give 1·5kW of heat. Its efficiency is, therefore, about 5 per cent. Put in another way, a bullock pro-

duces an average power of 80W and consumes about 2·7 tonnes (dry weight) of food in a year. To obtain 80W by burning wood would require 1·2 tonnes of wood.

Thus from the point of view of thermodynamics, the wood-fired steam engine has advantages over the bullock as a source of power. There is a further advantage in that the steam engine does not need to be supplied with fuel when it is not working or when it is too young or too old to work. It can, therefore, save fuel when power is not needed and use it all during the season when water pumping or ploughing is required. In addition, the steam engine will probably be used with more efficient pumps and ploughs than will the bullock. This may be a considerable gain as the efficiency of indigenous Indian water raising appliances is only about 35 per cent.

The disadvantages of the steam engine are high first cost, the lack of fuel and the lack of versatility. It would be difficult to use the same steam engine for pumping, ploughing and as a means of transport. These objections may well make the replacement of the bullock by the steam engine a very slow process. Nevertheless, it does seem desirable that a small steam engine fired by vegetable matter should be designed. It is possible that such an engine might be of value in some areas where coal and oil fuel are not available but wood or other suitable plants are.

The widespread use of plants as a source of power would require so large an area of ground as seriously to affect the area available for growing food. Spoehr points out[14] that if half the food produced in the United States during an average year, between 1913 and 1918, were fermented to alcohol, it would just be able to replace the 1920 gasolene production. This comparison shows how entirely inadequate such a source is to provide an amount of power comparable with that at present in use.

The above estimates are based on the rate of production of vegetable matter by existing plants. It is conceivable that higher rates could be achieved by breeding plants specially for high rates of production. This would only be possible if the rate of production were not limited either by the usable energy received or the amounts of carbon dioxide or other necessary material available.

Continuous Biological Photosynthesis.—It has been suggested that some form of plant could be grown in tanks and continuously withdrawn and burnt, or fermented to alcohol. The attraction of this scheme is that it provides a process by which mechanical or electrical energy can be obtained continuously from sunlight without the consumption of any material substance.

The efficiency of the photosynthetic process in systems of the kind contemplated is in some doubt. A reasonable guess would perhaps be that 30 per cent of the energy is used with an average efficiency of 25 per cent, giving an efficiency of 7·5 per cent for the transformation of solar energy into chemical energy. If the plant material were filtered off and burnt, about two-thirds of this energy would be obtained as useful heat; the remainder would be used in drying the plants and could not be recovered except at so low a temperature as to be useless for power production. This gives 5 per cent of the incident energy or 10 W/m² of useful heat. With a power station efficiency of 32 per cent, the power produced is 3·2 W/m². These figures are summarised in Table III. Fermentation of the plants to alcohol or methane is also possible, and perhaps more convenient, but would yield substantially less power.

Owing to its complication, such a scheme would only be possible on a fairly large scale. A power station producing 10,000kW would need 3·1km² of tanks. The depth of the tanks would have to be sufficient for the greater part of the light to be absorbed by the plants. It is not known what thickness is required, but it would probably be at least 30 cm. If this is so the volume of water would be $0·9 \times 10^6$m³.

The disposal of the heat not used by the plants might also be a serious problem, since for a 10,000kW station it would reach over 3×10^6kW at midday in summer.

On the figures given above, the scheme is clearly impracticable. An area of 3·1km² of tanks, which might have to be covered, is too great to be considered for the production of 10,000kW. A reduction at least by a factor of 10 is necessary. An examination of Table III suggests that this can only come from an increase in the efficiency of the conversion of the sun's radiation into chemical energy by increasing the range of wavelengths used or by increasing the efficiency of use of those wave lengths already utilised. On present evidence it does not seem that such substantial improvements are possible. If, at some future time, the cost of fuel becomes very much greater than at present, such possibilities might require serious consideration.

TABLE III—*Production of Power by Continuous Photosynthesis*

	per cent	W/m²
Solar constant	100	1300
Yearly average	15	200
7·5 per cent transformed to chemical energy	1·1	15
Useful heat	0·8	10
Useful work	0·26	3·2

DISTILLATION OF WATER

There is scope for the solar distillation of water for drinking purposes in certain tropical areas. On the assumption that an average of 0·15kW/m² of radiant energy is available, the evaporation by direct distillation at 100 deg. Cent. would be approximately 5 kilogrammes per square metre of heat surface per day. Distillation at pressure below atmospheric would not reduce the heat required per kilogramme of water, but the efficiency of heat collection would be greater because of the lower temperature. Considerable improvements have been made recently by introducing black dyes into the solution to increase the proportion of the heat absorbed.

There is considerable scope for a combination of solar heater and thermal pump. This system would enable almost complete recovery of the latent heat of condensation and would greatly increase the output for a given size of plant.

CONCLUSIONS

There is, at present, no way in which the use of solar energy can make a large contribution to our sources of power, and no line of research and development can be suggested that is likely to lead to a way in the near future.

Energy for domestic hot water heating can, in favourable circumstances, be obtained and there is scope in certain tropical areas for the distillation of water using a combination of solar heater and thermal pump. The committee recommends that a cooking stove, utilising solar energy and suitable for large-scale production, be designed.

The development of air-conditioning equipment, driven by solar power, is worth consideration, as is the design of a flat-plate collector for driving a small engine.

A small steam engine of high efficiency, using wood or other plant material as fuel, appears to have substantial advantages over power derived from animals for pumping water and driving light machinery. The development of such an engine is desirable, and is being undertaken by Ricardo and Co., Engineers (1927), Ltd., for the National Research Development Corporation.

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The Power-House at Maple Lodge Sewage Disposal Works

THE Maple Lodge Sewage Disposal Works of the Colne Valley Sewerage Board has already been described in these columns* on several occasions, as the progress of its construction warranted, so that many of our readers will already be familiar with the scheme. In this article, however, details are given of the dual-fuel engines and other equipment in the power-house, which supplements the information on this subject which we have already printed. All the power required for the various mechanised processes of the works, including lighting, is generated at the power-house, where there are six dual-fuel engines, each developing 666 b.h.p., and each coupled to 750kVA alternators. These machines are shown in the illustration on page 688 with the three electrically driven turbo-compressor sets, which supply low-pressure air to the aeration channels of the works in the foreground. On the left three control panels may be observed, the first two showing sewage flow indicators, integrators, summators and a mimic diagram of flow through the works, and the third air flow indicators, summators, and recorders, and the turbo-compressor speed control gear.

The six dual-fuel engines installed in the power-house had to comply with three conditions: (i) to give a specified output on gas operating under dual-fuel conditions, (ii) to give a specified output when operating on oil fuel, and (iii) to give a specified maximum output under pressure charged conditions using oil fuel. Each engine develops 666 b.h.p., when operating normally aspirated on sludge gas or fuel oil. During periods of heavy rainfall a considerable quantity of storm water has to be handled, and the pumping stations make a heavy demand for power. To meet this demand, two Holmes-Connersville Rootes blowers are arranged to furnish air at 4·2 lb per square inch to a bus main, enabling any two engines to operate as pressure-charged diesel units at very short notice. This obviates the need to start up another engine. When operating as a pressure-charged unit each engine develops 866 b.h.p. net output, after deducting the power required to drive the motor-driven blowers. Fuel oil is delivered by road tanker and sludge gas reaches the power-house at approximately 4in W.G. pressure. "Peebles" mercury sealed, gas pressure regulators reduce pressure to 0·5in W.G. for use in the engines. All gas used in the power-house is metered. Compressed air at 350 lb per square inch is stored in four vertical air receivers for engine starting. "Monitor" alarms fully protect the engines against low lubricating oil pressure and high cooling water temperature. Alarm controls, together with indicating lamps, klaxon horn and flasher lamp, are centralised on a wall-mounted instrument panel, and a smaller instrument panel for each engine carries all the usual engine instruments for lubricating oil, gas, pressure charge and starting air pressures. Each engine panel also carries exhaust temperature indicators and an electric tachometer, which incorporates an overspeed shutdown relay; this relay brings an electro-hydraulic thrustor into operation, which acts directly on the fuel pump control rod.

The Crompton-Parkinson alternators coupled to each dual-fuel engine generate at 3·3kV, 50 c/s. Electrical energy is generated at 3300V and is controlled by Ferguson Pailin metal-clad oil-immersed switchgear incorporating duplicate busbars, which makes busbar selection a fool-proof and simple operation.

* See THE ENGINEER, July 18 and Jan. 25, 1952, Jan. 6, 1950 and Oct. 31, 1947.

Power House at Maple Lodge Sewage Disposal Works

Each circuit breaker is mounted on its own transfer and transportation truck and is fitted with integral raising and lowering mechanism to facilitate busbar selection and breaker isolation. A mimic diagram is a feature of this switchgear ; lamp semaphores indicate the position of all circuit breakers.

Exciter control and neutral earthing cubicles house Metro-Vick automatic voltage regulators. Motorised speeder gear is fitted to all the engine governors and controlled from the switchboard. The synchronisation of alternators and the regulation of load is therefore under the direct control of the switchboard attendant.

Power at 3·3kV is supplied direct to the turbo-compressor motors and to two transformer sub-stations, one at Juniper Hill pumping station and one for the sludge filtration and drying plant.

Two Bruce Peebles stepdown transformers provide a 415/230V supply for power-house auxiliaries, lighting and mechanised plant on the disposal works.

Waste heat from the six dual-fuel engines is utilised for two main purposes—the maintenance of the sewage sludge in the digesters at a temperature conducive to maximum gas production, and the heating systems of power-house, administration building and workshops. The waste heat recovery system is divided into two independent circuits, providing low-grade heat and high-grade heat respectively. The first circuit utilises the heat from the engine cooling water up to 140 deg. Fah. This water is pumped from the hotwell through the sewage sludge digesters and returned to a storage tank. At times, the demand for heat in the digesters is less than that rejected to cooling water, and provision is made, therefore, to remove the surplus heat in Serck heat exchangers. Sewage effluent is used as the secondary coolant in these heat exchangers. Conversely, there are times when the heat is insufficient to maintain the sludge at the optimum temperature. On these occasions heat is transferred from the high-grade heat circuit through the agency of a Royle tubular calorifier. The supply of high-grade heat to the calorifier is controlled automatically.

Exhaust gas from engines Nos. 1 and 2 provides heat for the high-grade heat circuit, which is used either in augmenting the heat in the low-grade heat circuit, as already mentioned, or for domestic and space heating. All demands on the high-grade heat circuit other than by the low-grade heat circuit are supplied from the thermal storage tank. Two Spanner "Spiralflo" double-pass thimble-tube waste heat boilers, one Spanner "Spiralflo" vertical oil-fired boiler with Urquhart fully automatic oil burning equipment, one thermal storage tank and one Royle vertical non-storage calorifier are arranged in series on a ring main. Provision is made to isolate any of these appliances for maintenance or repair. Duplicate electrically driven Harland centrifugal pumps maintain circulation in this main. Heat input to the high-grade heat circuit is automatically controlled by the temperature in the thermal storage tank.

The three Reavell electrically driven, multi-stage turbo-compressor sets, shown in the foreground of our illustration, supply low-pressure air to the aeration tanks of the biological plant. Each compressor is driven by a 320 b.h.p. Crompton electric motor through a Vulcan Sinclair variable-speed fluid coupling and David Brown speed-increasing gearbox. Speed variation is by push-button control on the air metering panel, which also accommodates Kent rate of air flow indicators, integrators, summator and recorder, and air pressure gauges. In order to permit of the compressor sets being operated at the highest possible efficiency under varying pressure conditions, two complete sets of gears are available. At present the lower ratio gears are in use and, under these conditions, each blower delivers air at a maximum rate of 6500 cubic feet per minute (free air) and at a pressure of 7·5 lb per square inch. As the porous alundum air diffusers in the aeration tanks age, air flow will tend to become restricted and it will be necessary to fit the higher ratio gears in the gearboxes. The same quantity of air will then be delivered at 9 lb per square inch.

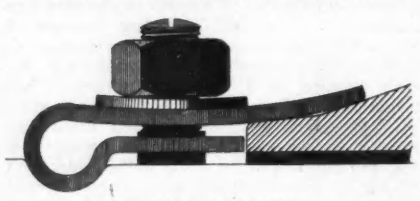
To safeguard the lighting of the power-house at night against temporary failure of the main lighting system, an "Austinlite" 5kW automatic lighting set is installed. A National 9 b.h.p., 1000 r.p.m. diesel engine is the prime mover. In the event of the main lighting switchboard becoming "dead," the emergency set starts up automatically and supplies current to the pilot lighting system within ten seconds.

The consulting engineers to the Colne Valley Sewerage Board were Messrs. Sandford, Fawcett and Partners, and the main contractors for the power-house equipment were the National Gas and Oil Engine Company, Ltd.

Conference on Rubber in Railway Engineering

IN order to give railway engineers and others concerned with the provision of rolling stock and equipment for railways an opportunity to hear of and discuss the recent developments which have been made in France in the use of rubber for railways, a conference was organised by the British Rubber Development Board. This conference was held in London on Thursday last, November 13th, and the delegates were welcomed to it by Sir Sydney Palmer, the chairman of the Board. Following a brief introduction to the recent developments in France, which was given by Monsieur B. Godefroy, of the Institut Francais du Caoutchouc, three papers were presented and discussed.

The first paper, "The Use of Rubber Rail Pads on the Permanent Way," was presented by Monsieur R. Sonneville, the chief of the research section (Permanent Way Department) of the S.N.C.F., and it was read for him by Mr. E. J. Pannell. In opening, the speaker pointed out that instructions were given in 1945 for research work to be carried out on rubber soleplates to be placed underneath rails. The object in view was defined as :—To make up for the lack of elasticity inherent in rail supports consisting of concrete sleepers, and, with the help of a rubber soleplate, to obtain an elasticity to simple compression under vertical loads which was comparable to that of wooden sleepers.



The "R.N." Rail Clip

As a result of the experiments which followed a soleplate with zigzag grooves on its upper and lower surfaces was developed.

Numerous tests carried out in regard to the spacing, depth and width of the grooves as well as the thickness of the soleplates themselves made it possible to determine the type which was most suitable. These soleplates, which were only 4½mm thick, had an elasticity to compression under the normal loads of wheels transmitted by the rail, which was slightly greater than that of wooden sleepers.

At the beginning of the researches a question had arisen as to whether the elasticity of the soleplates was sufficient. Their purpose was to deaden the dynamic effects transmitted by the rail, which the concrete could not stand. However, nothing was known about these dynamic effects, and this was the starting point for very important research work.

Monsieur Sonneville explained that when the wheel of a vehicle moved along the rail, the rail was first lifted slightly up to just in front of the wheel ; it was then abruptly lowered underneath the wheel, raised slightly just after the wheel had passed, and finally took up its position of equilibrium once again. This movement was very easily visible and was the more violent the more quickly the train was moving. A phenomenon which was analogous but more complex and much more accentuated occurred when each wheel passed over the rail joints.

A series of investigations with a specially designed machine and then on the tracks themselves with trains in motion were then described in detail.

The researches showed that the real cause of track fatigue and fatigue of track joints was high-frequency vibrations, which gave rise to alternate stresses which were higher the greater the weights which were moving. As a result of the frequency these alternate stresses were reproduced a great number of times with the passage of each wheel, on a sleeper, for example.

These considerations provided an *a posteriori* justification for the idea of grooved rubber soleplates. The amplitude of the elastic movements which the soleplate allowed for the rail was several tenths of a millimetre and, quite rightly, of the same order of size as the amplitude of the vibrations which had to be deadened. But these new facts regarding the dynamics of the track

also imposed certain necessities on the elastic fixings of the rail on to the sleepers.

These requirements were met by the "R.N." elastic rail clip shown in the accompanying diagram. The clip consists essentially of a manganese-chrome spring steel plate. Tightening of the nut on the plate to the correct amount brings about in conjunction with the rubber soleplate the required elastic shock-absorbing suspension of the rail on the sleeper. Monsieur Sonneville said that this doubly elastic fitting device fulfilled all hopes after five years' experience with it in service. The combination had produced a very strong and secure anchoring of the rail on all sleepers, in the face of vibrations due to the running of express trains. Now that the rail was pressed very firmly on the rubber soleplate, which had a very high coefficient of friction, it could no longer ride along longitudinally without bringing the sleepers along with it, and these were firmly anchored in the ballast. In this way it had been possible to satisfy the most difficult essential condition for welding rails over great lengths. After a cautious period of experimenting and a large number of measurements regarding the lengths of welded track which had become greater from year to year, the French Railways were welding rails over very great lengths. When the 1953 programme had been carried out there would be more than 1000km of welded track in France. The economic importance of this technique was very considerable, both in the increase in the life of all track materials and in the tremendous reduction in maintenance costs which resulted from doing away with joints.

Two films were then shown, one dealing with the development in the use of pneumatic tyres on French railways and the other on the experimental train fitted with pneumatic tyres and guide wheel running on a section of the Paris Metro.

In a brief paper Monsieur H. Ruhlman, the general engineer of the Paris transport system, dealt with the use of pneumatic tyres on the Paris Metro, and in it gave notes on the coach fitted with pneumatic tyres, the construction of which was completed about a year ago and which was put into service on the 800m long section from Porte des Lilas to Pre St. Gervais on April 13, 1952, after ten months of testing and adjustments.

He said that by November 1, 1952, this coach had covered 25,000km and given complete satisfaction as far as comfort, springing and silent running were concerned.

The vehicle weighed 40 per cent less than an ordinary vehicle of modern design, owing to the adoption of bus construction methods, which had been made possible on account of the suppression by the pneumatic tyres of the shocks and vibrations of the track.

Monsieur Ruhlman then gave some particulars of the plans which had been made to introduce the new design of coach on the Metro, and the advantages and economies which would accrue from using the pneumatic-tyred vehicles.

The last paper to be read and discussed was on main line expresses and underground trains running on pneumatic tyres, and it was presented by Mr. W. R. Good, of the Michelin Tyre Company, Ltd. After giving a brief history of rolling stock equipped with pneumatic tyres, he dealt with the problems involved in the tyres used, their design and development. He then covered the various aspects of railway working with pneumatic-tyred vehicles and the tracks, signalling, &c., with this class of vehicle in service.

A Flight Deck Arrangement for Aircraft Carriers

To increase the fighting power of the aircraft carrier the Royal Navy and Ministry of Supply have devised a new flight deck arrangement, and the idea is being developed simultaneously in the United States and the United Kingdom. Known as the "Canted Deck" and the "Angled Deck" in the respective navies, the concept, broadly speaking, involves laying out the flight deck plus a slight modification to its conventional shape to enable aircraft to fly on at an angle of about 8 deg. The arrangement was conceived by Captain D. R. F. Campbell, D.Sc., R.N., Deputy Chief Naval Representative, Ministry of Supply, in association with Mr. L. Boddington, Royal Aircraft Establishment, when studying the future design of aircraft carrier flight deck layout. At present the flight deck is divided into three areas. At the after end is the landing-on area and the arrester wires for engaging the hook of the landing aircraft and so bringing it to rest; next come the crash barriers, which operate when an aircraft overshoots the arrester gear and prevent it from crashing into aircraft and personnel assembled in the third area, known as the deck park, at the forward end. With the angled arrangement, should an aircraft not be brought to a standstill it can open up to full power and take off again without altering course and circle for another attempt to land. The conventional barriers can be eliminated, but an emergency barrier will still be required to cater for any aircraft unable, through defect or damage, to use the arrester gear. This new system should make barrier crashes rare and so contribute to the economy of carrier operations, while a further advantage is that the arresting area can overlap the parking area amidships. The angled layout, in effect, increases the length of the carrier by 40 per cent and makes it possible for more aircraft and also aircraft of better performance to be accepted. This new conception will improve the efficiency, economy and fighting power of carrier-borne aircraft, and following preliminary trials by both navies further development is proceeding.

The Cycle and Motor Cycle Show

THE twenty-seventh exhibition, organised by the British Cycle and Motor Cycle Manufacturers Union, Coventry, was formally opened by H.R.H. the Duke of Edinburgh, at Earl's Court, London, last Saturday, November 15th, and will close tomorrow. In the motor cycle section trends evident from previous shows are more clearly recognisable. The hydraulically-damped swinging arm rear suspension, largely a British development, is now fitted to at least one of the models of each main manufacturer. The division of motor cycles into two main groups is now more distinct. In the group including engines of 500 c.c. capacity and over, the B.M.W. transverse twin shaft-driven model constitutes the only serious challenge to this country's generally-recognised supremacy. In this class, a new model, the Royal Enfield "Meteor 700," of 692 c.c. capacity, is now the largest vertical twin-cylinder machine in production in this country. In the other main group fall what are generally termed the "lightweights," of capacities below 250 c.c. The better-known models have a cylinder capacity of 125 c.c., with petrol consumptions in the region of 85 m.p.g. Previously, these have been all two-stroke engines of single or twin-cylinder design, with the exception of the water-cooled "Velocette" twin-cylinder model. Amongst them is one claimed by the makers to be the cheapest motor cycle in the world, the James "Comet II," of 98 c.c. capacity, selling at £70 5s. 7d. (with tax).

The first overhead-valve engine introduced since the war in this class is a Triumph 150 c.c. model. It is credited with a top speed of 65 m.p.h. and a cruising petrol consumption of 160 m.p.g. In another class are the motorised cycles, with motors of 75 c.c. capacity or less. A Lohmann engine exhibited for the first time in this class has a compression-ignition engine of 18 c.c., developing 0·75 b.h.p. It is claimed to be capable of 20 m.p.h., and to have a fuel consumption of 350 m.p.g.

In the absence of a really cheap light car, the side car appears also to be in great demand, and in this section also are the three-wheeler cars from three different manufacturers. A significant trend in the bicycle section is the use of lighter and stronger tubing and for overseas models particularly, the use of oversize "balloon" tyres. There are a dozen exhibitors of tandems, and in the juvenile section a considerable selection of bicycles and tricycles is displayed.

Hydraulics Research

THE Hydraulics Research Division of the Department of Scientific and Industrial Research has just issued its first report covering the work from when it was set up in December, 1946, until December, 1951. Prior to 1947, little work was done in this country on such urgent problems of research as coast erosion, flood protection, and the silting and scouring of rivers, estuaries and harbours, and it is to be regretted that even after the division was established several years were lost before a site for a research station could be obtained. When, early in 1951, Howbery Park, near Wallingford, was acquired, its equipment began for work on the improvement of rivers and estuaries, coast protection, the design and improvement of harbours, for tests on proposed reservoirs and hydro-electric schemes, as well as for fundamental research which would eventually assist in the solution of problems. Construction was begun on two wave tanks, 120ft by 80ft by 2ft 6in deep, and on two 350ft long, 2ft 6in deep flumes, one 12ft and the other 5ft wide, for flume and channel experiments. Work on these tanks and flumes and the main office building was sufficiently advanced by the summer of last year for the headquarters organisation to be moved to the new site. Some time will, however, elapse before the workshops and service laboratories and the main building for the model investigations are all completed.

The report states that some of the more important work of the division will be in connection with coast erosion, a subject on which at present but little scientific guidance can be given to authorities concerned. It is proposed by the use of models of lengths of coast to study the whole problem systematically. In this connection, it is interesting to note that a wave tank 54ft long, 10ft wide and retaining walls 3ft high, has already been built and equipped with an oscillating paddle wave generator, to study the effect of sea walls and the beaches in front of them.

Peat Burning Gas Turbine

AN open-cycle, internal-combustion gas turbine to burn peat has successfully completed its initial test runs at the works of the makers, Ruston and Hornsby, Ltd., of Lincoln. The turbine, of 750kW capacity, has been built under contract to the Ministry of Fuel and Power as part of the research programme into the utilisation of peat resources (which is proceeding in collaboration with the Scottish Home Department, with the general advice of the Scottish Peat Committee).

During the tests, powdered peat was used. A system of feeding the peat and controlling its flow into the combustion chamber has been developed which enables the plant to be run as steadily with this fuel as with oil. Using the experience gained in these initial tests, the plant is now being prepared for prolonged running.

An advantage of this machine is that the hot exhaust gases are available for drying the peat. The heat available is insufficient to dry the peat from the raw state, when it contains about 90 per cent water, but the plan is to run the turbine in association with a special press designed to remove about two-thirds of the water from the raw peat. This system permits peat to be won independently of weather or season, which is in contrast to the conventional methods employing air drying. It is intended that the programme should culminate in transferring the turbine to a Scottish peat bog, where it will be combined with a press and a dryer, which are on order.

A ROAD MAP.—The Daimler Hire, Ltd., of 243, Knightsbridge, London, S.W.7, has issued copies of a specially designed road map for use by clients of its hire car service, with a particular view to assisting overseas visitors for the Coronation. The map, which is published by the Roadfinder Touring Service, 14, Arlington Street, Piccadilly, London, S.W.1, covers the London and Home Counties and only A and B roads are shown. It incorporates a useful index showing against the place name the road numbers of roads passing through it, mileage from London, and its map square reference. On the other side of the map is a large diagrammatic throughway map of London.

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SIMPLICITY IN GEARS

Simplicity is an accepted ideal in engineering design, but its attainment is rarely simple. For example, the simplest design for any machine may emerge, too late to be adopted, only after repeated revision of the best of a number of alternatives. It is, indeed, remarkable how often the human mind, faced by a problem, chooses at first a complex rather than a simple solution. Probably it does so because until experience has been gained, the problem is incompletely understood and its true nature may not be perceived until many machines of the adopted design have seen much service. It may be, too, that operating experience alone can prove the possibility of omitting details that the original designer dared not assume to be superfluous. A recent paper on the development of gearing standards, presented by Dr. Tuplin before the British Gear Manufacturers' Association, referred to surprisingly simplified methods of determining manufacturing dimensions of spur, helical and worm gears, and in particular to a design-procedure in which the nominal diameter of a gear is its outside diameter instead of the conventional pitch circle diameter. In examining the kinematics of mating gears, pitch circles are a convenience, but when separated from its mate, no involute gear has a pitch circle, and so use of that concept in routine design, though conventional, is not essential. It can tend to be unnecessarily restrictive in that it may deter the designer from making full use of the remarkable flexibility of the combination of the involute tooth-form and the tooth-generating principle. The aim of the proposal discussed at the meeting is to reduce the determination of manufacturing dimensions of gears to the utmost simplicity, whilst at the same time, applying the available flexibility to the extent that no job demands a non-standard cutter. It was argued that it is not necessary to mention pitch circles, addenda, dedenda or working pressure angles, and so they do not appear in the recommended procedure, and that procedure, by consequence, is much simpler than conventional ones. A similar proposal might have been made thirty years or more ago, except that at that time there was, probably, insufficient experience to demonstrate the reliability of the variety of tooth-forms that may be produced when conventional tooth-design is abandoned. In fact, designers dared not make such a proposal then.

The inspiration for suggesting the new procedure comes from a recognition of the need for showing, in new British Standards on gearing now being formulated, how even those without any special knowledge of the subject may achieve a sound design by rote. In reality, the proposals do not involve any new concept; their novelty is confined to simple use of basic facts. The proposals have already been discussed by the appropriate committee of the British Standards Institution, and they have been described in articles by Dr. Tuplin in our issues of March 21 and October 24, 1952. Those for standardisation of worm gears depart markedly from current practice in achieving consistency with what is proposed for other types of gear. There still remains the difference that whilst cutters for spur and helical gears need be standardised only in pitch and tooth-form, a worm wheel can be economically cut only by a hob that corresponds to its mating worm. There is thus a need to standardise worms and not merely pitches. The subject matter of Dr. Tuplin's paper before the British Gear Manufacturers' Association did not excite strong dissent, as was clear from the nature of those comments in the discussion which withheld full approval. It would, indeed, be true to say of some of them that they were concerned with failure of the proposed methods to offer advantage in fields that they were never claimed to cultivate! It was pointed out, for example, that a recommendation intended for use when selecting the axial pitch of a helical gear cannot be applied to the entirely different bevel gear. It was mentioned that avoidance of use of the involute function in determining gear dimensions still left its tabulated values applicable in certain mathematical operations that are never required in gear design. It was suggested that although a screw and a helical gear are identical in geometrical essence, the fact ought not to be regarded as helpful, because screw and gear are normally put to different uses. But there appeared to be no real objection to the proposed simplification and little or no expression of any chagrin that might have been expected to have been aroused naturally amongst such an audience by the suggestion that for a quarter of a century or so calculations of dimensions of several types of gear have been unnecessarily cumbersome.

Although the economic advantage of standardisation is undoubted, draughtsmen sometimes find it more troublesome to comply with Standards than to ignore them. An expressed aim of the new proposals is to give maximum encouragement to the use of the gearing Standards by presenting the methods of applying them so simply and comprehensively that it becomes easier to use them than not. It is intended to claim that there is a British Standard cutter for gears for any normal purpose, to show how to identify that cutter, and to demonstrate the determination of essential manufacturing dimensions of the gears; and it is intended that new British Standard gear specifications shall contain comprehensive design data expressed with the utmost simplicity and with no specialised terms. Although prolonged examination of the proposals may reveal difficulties, none was clearly shown at the meeting. But it is to be hoped that before the new gearing Standards are issued in their final form, every possible difficulty will have been examined and discussed. For, though it is true that the adoption of British Standards by any manufacturer is voluntary, those Standards are brought into disrepute if they are difficult to apply, or fail satisfactorily to cover a wide range. If after the scrutiny they are now being given, the new proposals are widely recognised as soundly based—as we think they must be—they could greatly simplify and no doubt cheapen the design and manufacture of gears for all but a few specialised applications.

THE STRIKING POWER OF A NAVY

The decision to scrap the British Fleet Aircraft Carrier H.M.S. "Formidable" follows soon after the announcement that Congress has approved the building of a sister ship to the United States 60,000-ton carrier, "James V. Forrestal," ordered in 1951. The "Formidable" was the first of six fleet carriers laid down between 1937 and 1939 and completed during the war. One—the "Victorious"—has been taken in hand for modernisation and all the remainder—including the "Illustrious," which has had a large refit with major alterations—require to be strengthened and reconstructed if they are to operate the latest types of jet aircraft. In the opinion of the Admiralty the complete modernisation of the "Formidable" would not be justified now that the "Eagle" is in service and the "Ark Royal" will soon be in commission, which well illustrates the difficulty, having regard to our limited resources, in maintaining a balanced carrier force of the strength required. The striking power of a navy to-day—the power to carry out an offensive overseas—is largely vested in aircraft and the fleet carrier is in consequence

given the leading position in the fleets of Great Britain and the United States. On the other hand, an offensive would be of no avail without the necessary protection for our sea communications and this requires the provision of a smaller type of carrier for anti-submarine operations—ships of the size and performance of the "Glory" class light fleet carrier. A third type of carrier will also be required in large numbers to provide air cover for convoys throughout their voyage. But in spite of the greatly increased weight and size of modern anti-submarine aircraft the provision of escort carriers should no longer present a serious problem, thanks to the development of the helicopter as an anti-submarine aircraft, and to the new steam operated catapult which can be installed and operated in a medium size merchant ship.

The scrapping of the "Formidable" also emphasises the large amount of leeway to be made up by this country if we are to regain our position as a first-class naval power. Even on the assumption that all the remaining ships of the "Formidable" class will be reconstructed and modernised—a doubtful assumption—we shall have, on the completion of the rearmament programme in 1954 or 1955 only eleven carriers capable of operating the types of aircraft required to meet enemy shore-based aircraft on equal terms. And this number includes the four much smaller but equally fast carriers of the "Hermes" class—an improved light fleet carrier—laid down during the war and now completing. According to Admiral Fechteler, who was earmarked for the post of Supreme Commander, Atlantic, but has since become Chief of Naval Operations, United States Navy, a typical Task Force consists of four large carriers, four cruisers and thirty-two destroyers, and in view of the heavy losses to be expected when carrying out offensive operations in enemy waters, it is clear that we must considerably increase the number of our carriers and cruisers (of which we have only twenty-four) as soon as circumstances permit. The position is not urgent at the moment, for the only Power with a large surface fleet is the United States. In addition to the two 60,000-ton carriers, the United States Navy has three carriers of 45,000 tons and twenty-four war-built carriers of the "Essex" class—27,000 tons—all of which have been, or are being, modernised; and it is hoped to build another 60,000-ton carrier each year over the next eight years. Indeed, we may well consider ourselves fortunate, during this period of new developments, when there are possibilities of atomic weapons and a new kind of battleship with guided rocket launching platforms in place of the flight deck of a carrier, that Britain is able to rely on the United States to provide the bulk of the ships required for the offensive in the event of war in the near future. Meanwhile, we are concentrating on building up our share of the necessary anti-submarine and anti-mine vessels to safeguard N.A.T.O.—and, incidentally, our own—sea communications. But it is not a position in which the Englishman who is proud of his country can take pride. Sea power made us a great nation and sea power alone will continue to maintain our prestige in time of peace and ensure victory in time of war.

In an address given recently in New York, Admiral Fechteler, when urging the need for more 60,000-ton carriers, made no reference to the use of the large carrier for strategic bombing—an argument consistently put forward by United States naval authorities since the war. They maintain that the bombing of hostile communications, submarine harbours and war potential factories and establishments is most effectively carried out by naval aircraft operating, with fighter protection, from carriers off an enemy's coast. The Chief of Naval Operations took his stand on the facilities required for operating modern aircraft, the dimensions and performance of which almost exceed the capabilities of even the 45,000-ton carrier "Midway." The mobility and manœuvrability of the large carrier, he added, make it a poor and unprofitable target for bombing attack. Emphasising that no man-of-war of any nation has ever been sunk while under way at sea by high-level bombing, Admiral Fechteler referred to a period of thirteen days during the Japanese war, when U.S. carriers operating in the Pacific were attacked by 141 suicide planes. All were shot down. During that same period aircraft from these carriers destroyed 2000 Japanese land-based aircraft before they could even get into the air. The 60,000-ton carrier, he concluded, is in no sense a "super carrier," but merely an orderly step in the natural and progressive development of naval aviation.

Obituary

SYDNEY BRYAN DONKIN

IT is with regret that we have to record the death of Mr. S. B. Donkin, which occurred at Winterfold, Albury, Surrey, on Wednesday, November 12th, at the age of eighty-one. He was the senior partner of Messrs. Kennedy and Donkin, of Westminster, the well-known firm of consulting engineers.

Sydney Bryan Donkin was born on June 24, 1871, and received his engineering education at University College, London. He served an apprenticeship with the Bryan Donkin Company and with Sulzer Brothers, of Winterthur, and in 1897 he became an assistant to Sir Alexander B. W. Kennedy, who was then in practice as a consulting engineer. Mr. Donkin was taken into partnership in 1908, and in 1913 the firm became known by its present title of Messrs. Kennedy and Donkin. Much of Mr. S. B. Donkin's work was concerned with the design of electricity generating stations, both thermal and hydro-electric, and of systems for the transmission and distribution of electric power. The works with which he was associated make an impressive list, including many major schemes well known to the world at large, as well as to the engineering profession. To take one aspect of his work, that of hydro-electric construction, it may be mentioned that he was a member of the Egyptian Hydro-Electric Power Commission, and was one of the engineers appointed in 1943 to re-examine the Severn barrage scheme. Earlier in his career he was concerned with the plant and transmission of power for the Foyers hydro-electric scheme at Kinlochleven, and he also contributed to the design of a hydro-electric development scheme in Japan, and the Uhl River scheme in the Punjab. In more recent times, his firm has been consulting engineers for the electrical and mechanical aspects of many of the schemes of the North of Scotland Hydro-Electric Board, including the Sloy and Affric developments, as well as for the Owen Falls hydro-electric scheme in Uganda and the Aswan hydro-electric scheme in Egypt.

However, Mr. Donkin's work was not by any means confined to hydro-electric design. His firm were the consulting engineers for the Central Electricity Board's grid scheme and for several regional schemes of this nature, and has been engaged in work for the British Electricity Authority since its formation. During the course of his career Mr. Donkin was concerned with power stations at Calcutta and Rangoon, and at Grove Road, Wimbledon, and Deptford, in London, to give only some examples. He was also interested in railway electrification, being concerned with the substations and distribution and power stations for this work.

Mr. Donkin was a full member of all three of the major engineering institutions. He became an associate member of the Institution of Civil Engineers in 1898, a full member in 1912, and was elected president

S. B. Donkin

for the session 1937-38. His presidential address was devoted to the progress of the application of electrical power, and the address contains many generalities and predictions of future trends that are not without interest to-day. He opened his remarks by quoting from an essay on applied science written by Shelley in 1810, in which the use of electricity had been discussed. Now, most of the things Shelley thought of had been done, Mr. Donkin noted, and mankind had benefited. Man had become a more efficient unit, he said; he performed more work in a given time, he lived longer, and he had greater comforts. But with all these advantages, Mr. Donkin continued, it was a misfortune that the necessity still arose for some to spend their energies and the wealth of their country in fruitless endeavours to kill, or to be ready to kill, their enemy in less time and at less cost than was possible for their adversaries. He found that the records kept by Professor Kennedy showed that, in the steam generating stations of the Westminster Electric Supply Corporation, Ltd., in 1891, the average consumption of coal was 10 lb per kilowatt-hour sent out and the works cost of generating those units with good Welsh coal was about 5d. per unit. In 1936 those figures

were 0·97 lb and 0·2d. for a power station with a thermal efficiency of 27·63 per cent. He outlined the various stages by which this development had been achieved, and by which future progress in the use of electricity as a commodity would, in his opinion, be furthered.

Apart from his presidency of the " Civils," Mr. Donkin was a vice-president of the Institution of Mechanical Engineers. He was president of the Association of Supervisory Electrical Engineers in the years 1928–31, and was twice chairman of the Association of Consulting Engineers in 1927 and in 1943–44, and was a Fellow of University College. He served on committees of the British Standards Institution and of the Department of Scientific and Industrial Research, and was a member of the General Board of the National Physical Laboratory from 1922 to 1927. Mr. Donkin was also a member of the Newcomen Society and of the Smeatonian Society of Civil Engineers.

The great variety of Mr. Donkin's interests in the engineering world will be evident from the foregoing account of his activities. He made a significant contribution to engineering, particularly to the application of electrical power, and his death will be regretted by very many engineers in all branches of the profession.

G. M. GULLICK, C.B.E.

We have learned with regret of the death of Mr. Geoffrey M. Gullick, which occurred in hospital at Sheffield on November 11th. Mr. Gullick, who was sixty-three, was the chief mining director of Mavor and Coulson, Ltd., Glasgow.

Geoffrey Gullick was born in London in 1888 and was educated at Dulwich College. On leaving school he determined that mining was to be his career, and in 1906 he was

G. M. Gullick

articled by his uncle, who was at that time the agent at Pemberton Colliery, Lancashire. It was actually during his pupilage that Mr. Gullick's long association with Mavor and Coulson, Ltd., began. In 1907, that firm supplied a coal cutter to the colliery at which he was working and, from the start, he took a keen interest in its operation. In the following year he started buying a machine himself and began cutting coal by contract at a tonnage rate, an enterprise in which he succeeded by hard work and his organising ability. By 1914, in partnership with his brother, Mr. Gullick was employing nearly 200 men in his coal cutting business. He served in the 3rd Battalion King's (Liverpool) Regiment throughout the first world war, and in 1919 joined the staff of Mavor and Coulson, Ltd.

As head of his firm's mining department, Mr. Gullick took a prominent part in the development of machine mining methods. He made a close study of the working of coal, not only in all the British coalfields, but also in most of the coalfields of other countries. By this means Mr. Gullick acquired a knowledge which enabled him to influence the development and application of all kinds of coal cutting machinery. In the second world war he was appointed adviser on mechanical mining and the supply of mining equipment to the Director-General of Coal Production, and subsequently became chief mechanisation adviser to the Ministry of Fuel and Power. In recognition of the services that he rendered in these important offices he was created C.B.E. After the war, Mr. Gullick returned to Mavor and Coulson, Ltd., as chief mining director. He was also a director of Mavor and Coulson (South Africa), Ltd., and a member of the council of the Institution of Mining Engineers.

Literature

Polarized Light in Metallography. By G. K. T. Conn and F. J. Bradshaw. London : Butterworths Scientific Publications, 4, Bell Yard, W.C.2. Price 21s.

In view of the long-established use of polarised light in petrology and mineralogy, it is at first sight surprising that similar technique has not been widely applied in metallography. There are several reasons for this. In the first place, the change from transmitted to reflected light involved drastic modification of the methods of preparation and examination of the specimen. Then, for a long period, microscopy of metals by ordinary light was so extraordinarily fruitful in results that no pressing need was felt to extend it to the use of polarised light. There was consequently a lack of interest in the subject among metallurgists, and also there was a complete lack of standardised equipment for the examination of specimens by reflected polarised light. A good deal of conflicting evidence was produced in the early work. False appearances were common. Scratches in the polished specimen, even when almost eliminated, gave bright reflections in the 45 deg. position and extinction when parallel to the plane of polarisation. Hence the value of electrolytic polishing for specimens of most materials intended for this method of examination. Electrolytically polished surfaces, free from scratches, gave greater grain contrast under polarised light than mechanically polished specimens.

Real advances in technique and interpretation began to be made subsequently to 1935, and the position is now such that an authoritative review of the subject is to be welcomed. This has been undertaken under the sponsorship of the Optical Methods Sub-Committee of the British Iron and Steel Research Association, of which Dr. Conn and Mr. Bradshaw, who are responsible for this book, are respectively chairman and secretary. The volume consists of seven chapters by different authors, each treating a separate aspect of the study of microscopy by reflected polarised light. The first three chapters are concerned with general principles, equipment and procedure. Chapter 4 deals with results of examination of metallic specimens, and chapter 5 with the study of inclusions in metals and alloys. Chapter 6 contains a discussion of the application of reflected polarised light technique in mineralogy, a field in which transmitted polarised light has yielded such outstandingly valuable results. Though there is scope for the wider use of reflected polarised light in the examination of opaque minerals and ores, it is unlikely to supersede the older methods in the examination of slags or of any material which can be produced in thin transparent sections. The final chapter, on the significance of polarised light microscopy in a study of metals and ores, is in the nature of a summary and is followed by a glossary of optical terms.

The interpretation of the patterns seen in the eyepiece of a polarising microscope involves consideration of many factors, and the first two chapters of the book are of essential importance to anyone intending to make serious use of the technique. The general reader, interested in results rather than methods, will be most appreciative of chapter 4 by Mr. E. C. W. Perryman and chapter 5 by Mr. H. Morrogh. Mr. Perryman describes the uses to which polarised light has been put in revealing grain structure, in the detection of preferred orientation, the examination of oxide coatings, the detection of internal strains and plastic deformation, and the identification of phases in multiphase structures. In this field of work polarised light microscopy would appear to provide differential modifications of intensity of illumination and of contrast, which require careful interpretation, rather than positive means of identification. Mr. Morrogh deals with the examination and identification of inclusions in metals and alloys. Scattered attempts have been made to apply the reflecting polarising microscope to the identification of inclusions with varying success. One great difficulty is that inclusions are usually very small particles which only rarely cover the field in view. Frequently they are polished in relief, and their surface geometry gives rise to effects which may easily be misinterpreted. Nevertheless, several kinds of inclusion show a reflection pleochroism which is quite characteristic and which permits their positive identification.

The book supplies a comprehensive survey of the present position and future prospects of the use of polarised light in the metallurgical microscope. It may confidently be commended to all metallographers who wish to extend their studies in this direction ; in fact, without the guidance which it affords, they may run a grave risk of reaching erroneous conclusions. To all those interested in the progress of metallography, it affords a valuable assessment of one of the recent advances in microscopical technique.

Street Lighting. By J. M. Waldram. London : Edward Arnold and Co., Ltd., 41, Maddox Street, W.1. Price 65s.

The subject of street lighting is very specialised and developments are taking place with some rapidity. Further, there are only a comparatively few large cities which are able to command the full-time services of a specialist in public lighting and, in the case of most local authorities, the responsibility for lighting the streets is taken by the city or borough engineer. This means, in effect, that someone on his staff has to combine the work of a public lighting engineer with a number of other duties. In these circumstances, it is inevitable that the actual work of laying out any particular lighting scheme should be done by the appropriate department of one of the large commercial organisations; the local authority, through their engineer, can only exercise a more or less general supervision in which attention is

inevitably largely concentrated on finance and on the mechanical and electrical (or gas supply) aspects of the problem, rather than on the lighting result which will be achieved. There is, therefore, great need for a really practical book which, placed in the hands of a qualified assistant to a city or borough engineer, will enable him to grasp the essentials of the problem looked at as a lighting problem. The Code of Practice recently issued by a joint committee of the Institution of Electrical Engineers and the British Standards Institution goes a short way in this direction, but something fuller and much more compendious is wanted and this need has now been admirably supplied by the publication of this book.

The author first deals with the basic principles of street lighting, including a brief, but very necessary, treatment of the phenomena of vision as far as they affect the visibility of objects on the street. He then goes on to discuss the appearance of the lighted street, the effects of the colour of the light, the influence of atmospheric conditions and, finally, glare. His next three chapters are concerned with what may be looked upon as the instruments which the lighting engineer must use in judicious combination to achieve a satisfactory result. They are, respectively, the light distribution from the lanterns, the height, spacing and arrangement of the sources and the nature of the road surface, as far as this affects its reflecting properties.

The next five chapters form Part II of the book, under the general heading "Layout and Installation Design." Here, the author places at the disposal of his reader the digested results of many years of practical experience in design. He has had unrivalled opportunities, during the past twenty-five years or more, to study installations of all kinds, both good and bad, at home and abroad, and to analyse the problems involved. He has, during this time, written many papers on the subject and now he has brought together, concisely and with mature judgment, the results of his own work and that of other specialists in this particular field, work which is described in a large number of papers scattered widely in the literature.

The third part of the book is the longest, and deals with the equipment available. The first chapter in this part describes the various electric light sources used for street lighting, while the next two chapters cover the many kinds of lanterns which have been designed for use with such sources. There are also two chapters dealing, respectively, with columns and suspensions and with the different distribution and control systems used in electric street lighting. This part also contains two chapters, one on gas light sources and the other on lanterns for street lighting by gas. These chapters and a later chapter on control devices and auxiliaries for gas lamps, have been contributed by Mr. L. T. Minchin, an expert on gas street lighting and at one time a member of the research staff at Watson House.

The fourth and final part is short and contains only two chapters, one dealing with costs, maintenance and the relation between street lighting and accidents, the other with photometric measurements and other tests and with the photography of a lighted street.

Four useful appendices complete the book. Three of these give formal definitions, lamp data and the like; the other describes methods of making the various calculations involved in the design of a street lighting system. There is a moderately good index. The paper and printing are good and the illustrations, many of them half-tone reproductions of photographs, are of high quality—a matter of great importance in any book on lighting and a justification of the apparently high price.

SHORT NOTICES

Problems of Power Transmission at Voltages Above 225kV. By Professor François Cahen. London: The British Electrical and Allied Manufacturers' Association (Inc.), 36 and 38, Kingsway, W.C.2. Price 5s.—In March, 1951, Professor François Cahen gave a series of four lectures at the University of London, and they were subsequently published in the *Beama Journal*, September-December, 1951. Now the lectures are published in the form of a sixty-four-page paper-covered book. In the first section of the book the author surveys the problems of power transmission at extra high voltages. He introduces the subject by explaining why transmission voltages tend to be raised as power systems develop, and he goes on to examine the factors which determine the choice of new voltage levels, and to consider some of the technical problems that arise in insulation and system layout. Many of these problems are directly associated with corona, and two sections of the book are devoted to various aspects of this subject. One section begins with a general discussion of corona and proceeds to examine current knowledge of corona losses in the light of experimental research and theoretical studies concerned with the effect of conductor diameter, surface condition and weather on corona. In the next section the author discusses the use of multiple conductors and deals with corona from the point of view of radio interference. Finally, Professor Cahen examines the effect of overvoltages and surges caused by internal and external disturbances and reviews modern theories for the protection of equipment and co-ordination of insulation.

Energy Retrospect. By J. H. M. Sykes. London: Garraway, Ltd., 11a, Kensington Church Street, W.8. Price 6s. 6d.—This book, with its foreword by Sir Arnold B. Gridley, forms an amusing commentary on the present-day use of coal, gas, electricity and oil for industrial and domestic purposes. It takes the form of an imaginary discussion between a professor and two of his research students towards the end of the present century: the discussion arises from the divergent views expressed by the students in their papers on "The Economic Problems of Energy in the 1950s." In this discussion the professor acts as referee and of the two students it is "Mr. Wright" who has the last word on the means of saving coal from burning. This is what he says: "I would have advocated an extensive campaign for increased research into atomic energy. I should have pushed ahead with utilising the tides and the wind and of joining in with the Continent electrically at a much earlier date than we did, so that we could share their water power reserves. Then I should have advocated bringing electricity to the same state in regard to its availability as they had achieved at that time for water."

Materials Handling in Industry. London: British Electrical Development Association, 2, Savoy Hill, W.C.2. Price 8s. 6d.—This is the fourth volume of a series of eight books which are being published by the Association dealing with specialised industrial applications of electricity. It deals in some detail with the many kinds of mechanical handling devices in general use and their construction, characteristics and duties. By giving these details in a concise form it is hoped that the book will make it possible for prospective users to select the device most suited to the particular handling problem involved. It is pointed out that a majority of handling equipment is electrically operated, and with the use of the right plant productivity can be increased with reduced power costs. The book opens with notes on the benefits of mechanical handling and goes on to deal with relative factors and the application of mechanical handling equipment. Subsequent chapters give notes on all kinds of overhead runways, cranes, conveyors, elevators, floor transport and storage, vibration, &c.

The Metals Economy Advisory Committee

In August, 1951, the then Minister of Supply, in conjunction with the Minister of Materials, set up a committee to study "ways of economising in the use of scarce metals in the design, specification and the manufacturing process of metal goods, for both rearmament and civil purposes, and to advise the Government how it can best assist in promoting such developments." This week, the committee—of which Mr. D. A. Oliver is the chairman—has issued its first report (H.M. Stationery Office, price 9d.).

The report says that the shortage of alloying and non-ferrous metals which threatened British industry in 1951 is no longer critical, but supplies of many metals are still only sufficient for essential needs and there is little margin to meet unforeseen demands or a possible deterioration in the supply situation. The need for economy is, therefore, still urgently necessary. The expansion of world production and the operation of the International Materials Conference have increased beyond expectation the supplies of non-ferrous metals available to the United Kingdom this year. At the same time, the committee considers demands have been reduced because of the slower rate of progress in Western Defence programmes than was formerly expected, by economies made in industry, by Governmental restrictions on the use of metals and by the shortage of steel, which has caused a drop in the demand for associated metals. It is added that only in the cases of lead and zinc have the metals shortages of eighteen months ago entirely disappeared. Nickel, cobalt and copper, in particular, are still causing concern, and a sufficient supply of other metals for essential purposes can be maintained only by restrictions on less essential uses.

The report goes on to say that although on current forecasts we can expect to get through the next two years without any serious metals crisis, this may prove to be too optimistic a picture. There is little margin in estimated supplies to meet unforeseen demands or to build up stocks to offset any possible shortages in supply due to causes outside the United Kingdom's control.

In assessing the demand for the main metals, some allowance has been made for increased production in the metal consuming industries. But if the rise in production is greater than foreseen (and clearly it must be hoped that this will be so) the demand for metals will be intensified. The report reviews the work done by Government and industrial organisations to promote metals economy. Industry, it says, has been fully alive to the importance of economy and has done much to reduce its requirements of scarce metals by re-designing products, substituting more readily-available materials and by other methods. It is through the efforts of industry itself, the committee observes, that the greatest economies can be made.

Among the recommendations made in the report are that Government research establishments and private research associations should continue to experiment on the better and more economical use of metals; that the Defence Departments should ensure that designs and specifications for defence material are drawn up so as to achieve the maximum economy of metal; and that as much information as possible on future supplies of metal should be given to industry at regular intervals.

BOOKS RECEIVED

Electric Fuses. By Dipl. Ing. H. Lapple. London: Butterworth's Scientific Publications, Bell Yard, Temple Bar, W.C.2. Price 25s.

Rewinding and Repair of Electric Motors. By Karl Wilkinson. London: E. and F. N. Spon, Ltd., 15, Bedford Street, W.C.2. Price 20s.

Works and Buildings. By C. M. Kohan. London: Her Majesty's Stationery Office, Atlantic House, Holborn Viaduct, E.C.1. Price 32s. 6d.

Journal of the Institute of Metals. Edited by N. B. Vaughan. London: The Institute of Metals, 4, Grosvenor Gardens, S.W.1. Price 30s.

Radio Interference Suppression. Second Edition. By G. L. Stephens. London: Iliffe and Sons, Ltd., Books Department, Dorset House, Stamford Street, S.E.1. Price 10s. 6d.

Mechanism of Work-Hardening of Metals

By PROFESSOR N. F. MOTT, M.A., D.Sc., F.R.S.*

This, the thirty-ninth Thomas Hawksley Lecture, was presented by the author before the Institution of Mechanical Engineers last Friday, November 14th. The most striking feature of the deformation of metals is the formation of slip lines. Recent investigations suggest that, when formed at low temperatures, each slip line is the result of a displacement of the material along a single lattice plane through a distance of about a thousand atomic diameters. Moreover, there is much evidence that the steps on the surface which appear as slip bands attain their full height in a small fraction of a second, though their length may thereafter increase slowly. At higher temperatures and at slow rates of strain the slip bands appear, under the electron microscope, as clusters of lines about a hundred atomic diameters apart. The origin of slip lines, the reason for this clustering and the cause of work-hardening are discussed. The two conceptions used in the discussion are the dislocation line and the vacant lattice site.

Introduction

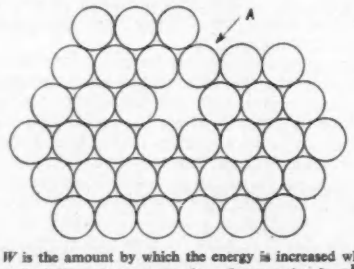
My aim in this lecture is to present a model of what happens when a metal work-hardens. I shall try to base my model as much as possible on experiment, but none the less it will contain a number of unproven hypotheses, and may be wrong in certain points. My object in putting forward an unproven theory is to stimulate experiment; that is the function of theories, and it is in the unproven state that they are most interesting; once they are shown to be right or wrong they can be relegated to the text-book or to oblivion.

The theory will be based on the assumption that the crystalline structure of a metal is marred, not only by obvious and visible defects such as grain boundaries, but by defects of two other types. These are (1) vacant lattice sites, and (2) dislocations.

My first task will be to explain what I mean by these, and to give experimental evidence that they exist.

Vacant Lattice Sites

By a vacant lattice site I mean a point within the crystalline structure of a metal from which the atom is missing. Such sites can be envisaged to be formed at moderately high temperatures at the surface of a crystal, at points such as *A* in Fig. 1, and to migrate inwards. In a crystal in thermal equilibrium at a finite temperature, a number of



If W is the amount by which the energy is increased when a vacant site is formed, the proportion of vacant sites is $e^{-W/kT}$. At the melting point this is 10^{-3} to 10^{-4} or less than 0·001 per cent of all sites.

Fig. 1—Vacant Site in Metal

such sites must exist. If W is the energy necessary to form a vacant site, the proportion of such sites will be $e^{-W/kT}$.

It is believed that self-diffusion in metals, and indeed diffusion of substitutional impurities generally, takes place through the agency of vacant sites. The vacant sites wander about in the lattice, and an atom will change places only when it is next to one. This hypothesis was put forward first by Johnson (1939); recently, it has received experimental proof from several sources (Smigelskas and Kirkendall, 1947; Correa da Silva and Mehl, 1951; Barnes, 1952; Nowick, 1951), of which the most striking is perhaps some recent results obtained at Harwell by Dugdale (1952). The workers at Harwell introduced vacant

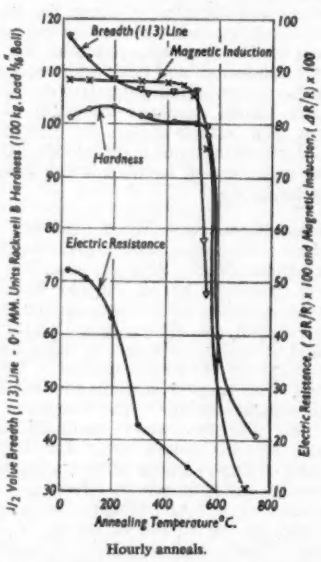

Breadth (113) Line
Magnetic Induction
Hardness
Electric Resistance
½ Value Breadth (113) Line - 0·1 MM. Units Rockwell B Hardness (100 kg. Load ⅛" Ball)
Electric Resistance, (dR/R) x 100 and Magnetic Induction, (dB/B) x 100
Annealing Temperature °C.
Hourly anneals.

Fig. 2—Effect of Annealing Temperature on Various Properties of Nickel

sites and, in addition, interstitial atoms into metals by fast neutron bombardment in the Harwell pile. On applying this treatment to a partially ordered copper-gold alloy of the type Cu_3Au, they found that the electrical resistance *decreased*. They interpreted this result as showing that the vacancies allow diffusion to take place at, or slightly above, room temperature, so that the degree of order can increase, and the resistance consequently decrease.

The importance of these considerations for the subject of this lecture is, as I shall show, that when a material is cold-worked, a large number of vacancies are formed; so that self-diffusion is allowed at temperatures where this normally would not be possible. So in examining self-diffusion, and the phenomena which depend on it, such as recovery, there are *two* ranges of temperature to consider.

First there are the temperatures which are high enough for vacancies to be formed and to move about. At these temperatures atoms can change places; self-diffusion is possible. At a lower temperature vacancies formed by some non-thermal process such as neutron bombardment can move, but new ones will not be formed. Diffusion is, then, possible only if vacancies are formed in some such way. At lower temperatures diffusion is in no case possible.

TABLE I—*Approximate Values of the Temperatures T_1 and T_2*

Metal	T_1 (deg. Cent.)	T_2 (deg. Cent.)
Copper	− 40	410
Lead	−130	1·0
Iron	80	800
Al minium	− 70	300
Platinum	160	1,000
Nickel	120	800

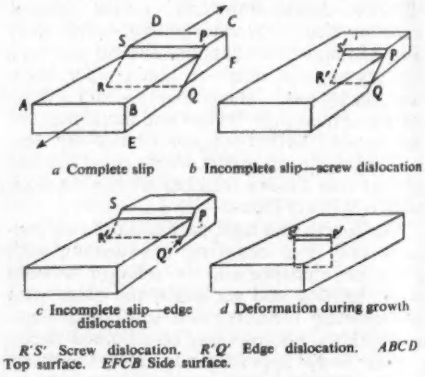
Above T_1 vacancies can move if formed by neutron bombardment or cold work, above T_2 they are formed thermally, so that self-diffusion and recovery are possible.

Table I shows the two temperatures as closely as I have been able to estimate them, for a number of metals. Later in this lecture I shall propose—following Seitz (1952)—that cold-working produces vacancies; the lower of these temperatures is therefore of importance in the theory of cold-work. Below it the vacancies cannot move. We believe that a large part of the enhanced electrical resistance of a metal cold-worked below this temperature is due to vacancies, which increase the resistance in the same manner as would impurities. Fig. 2, due to Wilson and Thomassen (1934), shows how this increased resistance diminishes, on heating, long before any recovery of the mechanical properties occurs.

Dislocations and Slip Bands

The second type of imperfection is what we call the dislocation. But before introducing this, I should like to remind you of what is known about the mechanism of slip in metals. In mechanical deformation at ordinary speeds and moderate or low temperatures, the deformation is all, or nearly all, concentrated in slip bands. I would like to say something about the geometry of these slip bands. This is shown schematically in Fig. 3, which represents a crystal under tension as shown by the arrows: PQ being the slip direction and $PQRS$ the active slip plane. Complete slip can be envisaged—as in Fig. 3*a* in which the whole cross-section of the crystal has slipped—or incomplete slip—as in Fig. 3*b* and *c*, in which the region that has slipped is bounded by a line such as $R'S'$ in Fig. 3*b*, or $R'Q'$ in Fig. 3*c*. These lines are centres of strain in the crystal; we call a line of the type $S'R'$ a screw dislocation and a line of the type $R'Q'$ an edge dislocation.

Usually the term dislocation is used for the lines bounding a plane that has slipped



a Complete slip *b* Incomplete slip—screw dislocation

c Incomplete slip—edge dislocation *d* Deformation during growth

$R'S'$ Screw dislocation. $R'Q'$ Edge dislocation. $ABCD$ Top surface. $EFCB$ Side surface.

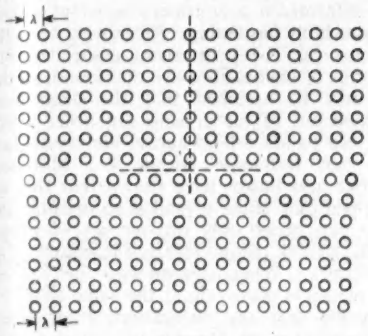
Fig. 3—Types of Slip in Crystals

through only one atomic distance. The slip lines observed in crystals are the result of slip through about a thousand times that distance. The lines bounding such planes I shall call dislocations of high order, or "piled up groups" of dislocations.

*Director of the H. H. Wills Physical Laboratory, University of Bristol.

Fig. 4 shows a representation of the position of the atoms in a dislocation of an edge type. A point that should be emphasized is that a row of atoms terminates on a dislocation line, as in Fig. 4.

Recent work with optical and electron microscopes has done much to elucidate the



The dislocation can be regarded as formed by adding the vertical dotted half plane or by subtracting the corresponding half plane in the lower half of the crystal.

Burgess vector

Fig. 4—An Edge Dislocation (Seitz 1952)

nature of these steps on the surface of deformed metals. According to Heidenreich and Shockley (1948), and particularly to Brown (1949, 1951, 1952), at low enough temperatures (−180 deg. Cent. for aluminium) the steps are single and of height about 2000 Angstrom units, which corresponds to a displacement of about a thousand interatomic distances. In cubic metals, at any rate, the complete step is formed in a very short interval (less than 0·01 second), and does not thereafter increase (or decrease under reversed stress). The end of the step (point S' in Fig. 3) may, however, move slowly across the crystal as the stress is increased (Chen and Pond, 1952). In terms of dislocations this would mean that screw dislocations can move slowly but that edges normally move rapidly.

Slip bands formed at somewhat higher temperatures—for example, room temperatures for aluminium—when examined under the electron microscope using oxide replicas, are shown to consist of a cluster of steps each of about the same height as that formed at low temperatures, separated by about 200 A, as illustrated in Fig. 5 (Brown 1952). The higher the temperature and the lower the rate of deformation, the greater is the number of such steps in each band. This has been ascribed by Brown (1952) to an annealing which takes place after slip in the immediate neighbourhood of a slip band. I believe that this is associated with the movement of the vacancies formed by slip, in a way that will be described later in the lecture.

The experimental facts about slip can thus be described as follows : plastic deformation, at any rate at low temperatures, is a succession of very rapid events, each lasting a small fraction of a second. In each of these events, slip, over about a thousand atomic distances, occurs on a given slip plane and extends over an area of the order of one square millimetre. When this area is bounded by a free surface a slip band is observed there. At moderate temperatures, the region in the immediate neighbourhood of a plane that has already slipped is particularly likely to slip again ; thus, under the electron microscope, the " cluster " of slip bands illustrated in Fig. 5 is seen. Slip bands do not, however, necessarily extend right across a surface ; they sometimes terminate ; and the line (within the crystal) on which the slip terminates is called a dislocation.

The study of these steps on the surface of crystals, by means of the optical and electron microscopes, forms one of the most rewarding branches of solid-state physics. It gives information not only about slip, or plastic deformation, but also about the growth of crystals. In growth from solutions or from vapour we have found that crystals normally grow by rotation of the step shown in Fig. 3 about the point where it is anchored to the screw dislocation. Atoms coming in from the vapour or solution adhere most easily to the step and, as they adhere, the step must move forward, rotating about its fixed point. Each time it goes round, a new layer is formed. As it rotates, it curls up into a spiral. Spiral markings have been observed on a number of crystals (Frank 1952), and in our laboratory it has been possible to make a film of the rotating spiral. We have distinguished cases where the height of the step is just one lattice parameter, and others in which it is several hundred times as high, as are the steps observed after plastic deformation. The techniques by which these steps are rendered visible are interesting ; but I cannot go into that subject here. I would, however, emphasise that crystal growth is associated with the movement of steps, while plastic flow involves the movement of

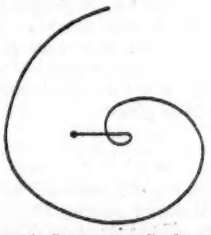
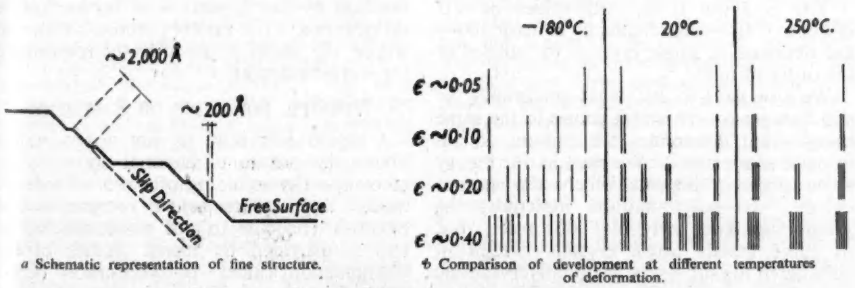


Fig. 6—Growth Steps on a Surface where Slip has Occurred After Growth is Complete

the dislocation—or, on the surface, the movement of the point where the dislocation ends. If, therefore, on the surface is seen a pattern like that in Fig. 6, this must mean that the crystal has suffered plastic deformation *after* growth has ceased. More complicated patterns will occur if the crystal has been deformed during growth. Now the study in our laboratory of growth steps on natural beryl crystals (Griffin 1952) has shown that that actually does occur ; so these apparently non-ductile materials can be ductile and, at any rate, have been so during their history.



a Schematic representation of fine structure.

b Comparison of development at different temperatures of deformation.

Fig. 5—Slip Bands (Brown 1952)

I would like to show you now what happens to a step on the surface of a crystal which terminates at *both* ends (Fig. 3(*d*)). This can be understood from Fig. 7 ; by growing outward the step can generate a complete ring, and, in doing so, reconstitute itself. At Bristol University we have been able to

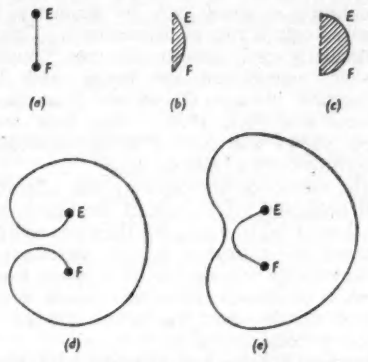


Fig. 7—Crystal Growth on a Surface with Two Dislocations, or the Action of a Frank-Read Source

photograph the occurrence of this process on cadmium iodide, and take a film of the process.

Plastic Deformation and Work-Hardening

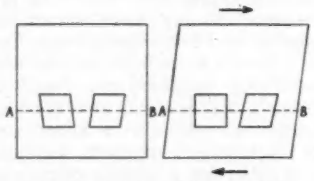
After this digression on crystal growth, I must return to my main theme, plastic deformation and work-hardening. The first task of a theory must be to explain why slip occurs only on selected planes that are at a distance of a micron or so from one another, and why slip, especially in single crystals, occurs for such low stresses. I think it is fair to say that this is now completely understood in terms of a model due to Frank and Read (1950). This model has been discussed in a number of articles and lectures, and I do not propose to spend much time on it here. But it depends on the assumption that metals, whether they are polycrystalline or are single crystals, contain dislocations ; in an annealed material these are perhaps 10^{-4} cm. apart ; and Frank and Read showed that with very reasonable assumptions regarding the arrangement of the dislocation lines, they would act as sources—about 10^{12} of them per cubic centimetre—from which slip could start and spread out. In order to see how this can occur, let us imagine that the line EF of Fig. 7 is a dislocation line which at points E and F leaves the plane of the paper. An arrangement of dislocation like this is what we call a Frank-Read source. When a stress is applied to the material the line will move in exactly the same manner as the step did ; but now the line is a dislocation line, that is to say, a line that separates the region that has slipped from the region that has not. The region that has slipped is shown shaded in Fig. 7. The " source " can thus generate a ring and, indeed, an indefinite number of rings, without being itself destroyed. Slip therefore can start at these points, spread over the whole slip plane, and continue until the displacement on the slip plane is indefinitely large. Moreover, the stress necessary to make the process work can be calculated and is about Gb/l, where G is the shear modulus, b the lattice parameter, and l the distance between the two ends of the dislocation line. If l is taken to be 10^{-4} cm., this gives values near to the yield points of single crystals of metals.

The model, then, appears satisfactory, provided we accept the hypothesis that metal crystals, in the annealed condition, contain dislocations. But this hypothesis is really not new, it is very old. On the basis of evidence

from the intensities with which X-rays are reflected from crystals, it has for a long time been accepted that most crystals are not perfect, but have some sort of mosaic structure. But recent analyses (Read and Shockley, 1950, 1952 ; Shockley 1952) have shown that any mosaic boundary or boundary between two grains at which the change of orientation is small, can, by geometry, be resolved into a row of dislocations. This is particularly well shown by the " bubble models " developed by Bragg and his colleagues in the Cavendish Laboratory (Lomer and Nye, 1952). Fig. 3 of their paper shows well how a mosaic boundary splits into a row of dislocations.

The sources of slip lines are thus tolerably well explained ; the bulk of the lattice has the theoretical strength, but there are sources —about 10^{12} of them in a cubic centimetre— at which slip will start when a much lower stress is applied ; and once it starts it will spread rapidly over the whole slip plane, unless something stops it.

So far, I have been dealing with ideas which, at any rate for the last year or two, have been common knowledge among metal physicists. Now I would like to turn to more speculative matters—namely, how does slip on these planes increase the hardness of the material ? On this subject, I would remind you first of Taylor's famous model of work-hardening, which he introduced in 1934



a Internal strains. *b* Stress applied

Fig. 8—Internal Strains in a Metal Crystal

(Taylor, 1934). Taylor introduced the hypothesis that a cold-worked material contained dislocations, that round each dislocation the material is elastically strained, and that these strains hindered a dislocation from moving. This model was generalised by Mott and Nabarro (1948), who developed a theory according to which the high yield of an age-hardened material was due to internal strains round the precipitates. The theory suggested that if a material contained internal strains as in Fig. 8(*a*), homogeneous over a few hundred atomic distances perhaps, no dislocations could move over large distances unless a stress were applied, as in Fig. 8(*b*), large enough to ensure that the strain throughout was everywhere of the same sign. This hypothesis concerning hardness can be applied to Frank and Read's model ; unless the strains are as in Fig. 8(*b*), none of the sources will generate slip bands.

Strain Hardening

I will now outline the quantitative theory of strain hardening, which is the main subject of this lecture. I believe that Taylor's model is essentially correct. Hardening is due to dislocations—or rather to the strains round dislocations. But the dislocations are not arranged at random throughout the solid in the way that Taylor postulated ; they are arranged, rather, *at the ends of slip bands*. It is frequently observed that slip lines terminate as in Fig. 9 ; they do not always run to the edge of a crystal. And, as I have already emphasised, at such points a dislocation of high strength must enter the crystal.

Let me try to deduce a stress-strain curve from this hypothesis. Suppose that the magnitude of slip on each active plane is n atomic distances. Then the strain, at a distance r from the end of one slip band is of the order,

$$\sigma \sim nbG/r,$$

where G is the shear modulus and b the interatomic distance. So if x is the distance between slip lines and L the mean length of a slip line, we may write the mean internal strain as

$$\sigma = nbG/\sqrt{(xL)} \quad . \quad . \quad . \quad . \quad (1)$$

This, according to my hypothesis, is the flow stress of the material for a given state of strain. The strain, on the other hand, is

$$\epsilon = nb/x \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

We can eliminate x between these two equations and obtain

$$\frac{\sigma}{G} = \sqrt{\left(\frac{nb}{L}\right)}\epsilon^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This begins to look like a parabolic stress-strain curve. It would be so if I could prove

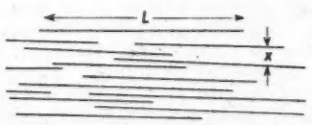
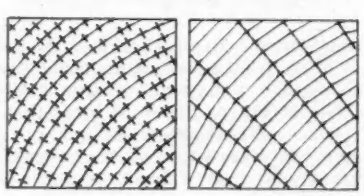


Fig. 9—Idealised Slip Lines on the Side Surface of a Crystal, and the Meaning of the Quantities x and L

that n/L were constant—independent of L and independent of the applied stress. I think this can be proved if certain hypotheses are made concerning the nature of the Frank-Read sources. I do not want here to go into the details.† But the basic idea is something like this. Once a source has initiated slip, it goes on generating " dislocation rings," according to the mechanism illustrated in Fig. 7. It will go on doing so until the stress set up at the strained region at the end of the slip band is big enough to stop it. Now clearly the bigger the value of L, that is, the bigger the slip distance, the bigger must be the distortion at the end to stop a source from acting in the middle. This is why n is proportional to L. A detailed analysis gives

$$\frac{\sigma}{G} \sim \sqrt{\left(\frac{Y}{G}\right)}\epsilon^{\frac{1}{2}},$$

where Y is the yield point of the unstrained material ; in other words, Y is the stress (of order Gb/l) required to make the sources

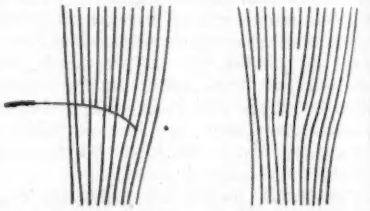


a As bent. *b* Annealed.

Fig. 10—Polygonisation of a Bent Crystal

act. Such a formula gives a stress-strain curve very much of the observed type, since $\sqrt{Y/G}$ is about 0·01, and values of σ/G of about 0·01—a hardening by a factor 100—are obtained in single crystals for strains of the order of unity.

We now have to ask, what determines the slip distance L—or, and it comes to the same thing—what determines the amount of slip in each slip plane ? We need in our theory some obstacle beyond which slip cannot extend. In polycrystalline materials, the grain boundaries may play this role ; but in cubic metals single crystals harden in very much the same way as do polycrystalline materials. Therefore, in single crystals, barriers to slip must exist. I think that the phenomenon of " easy glide " provides the clue to this. Thanks to the work of Andrade and Henderson (1951), Masing and Raffelspeiser (1950), Lücke and Lange (1952), and others, it seems to be well established that very pure single crystals of most metals can be deformed to a considerable extent without appreciably hardening. Moreover, when this occurs the X-ray asterisms associated with groups of dislocations are not found, so that it may be assumed that the dislocations escape out of the crystal. In other words, all slip bands extend across the crystal, and do not terminate within it. Moreover, Lücke and Lange have shown that this will happen only if the crystal is so oriented that slip can occur only on one set of planes. This, I think, shows clearly the nature of the obstacles. When slip on two inclined sets of planes is occurring at the same time, it is possible that the dislocations meet. Now theoretical work (Lomer 1951, and Cottrell 1952), has shown that when dislocations on inclined planes meet, they can join up and form what we have come to call a " sessile " dislocation. This is a dislocation which is unable to move. We believe, then, that in addition to grain boundaries, these sessile dislocations are the obstacles that stop the glide on a given plane from proceeding right out of the crystal. They doubtless play another important part, too. It has never been immediately obvious, with any dislocation theory of plastic flow, why the whole process should not be reversible ; or why the dislocations in the highly strained regions do not, when the applied stress is released,



a A piled-up group of dislocations in a work-hardened material. *b* Suggested form of piled-up group after thermal softening.

Fig. 11—The Processes Responsible for Polygonisation and Recovery

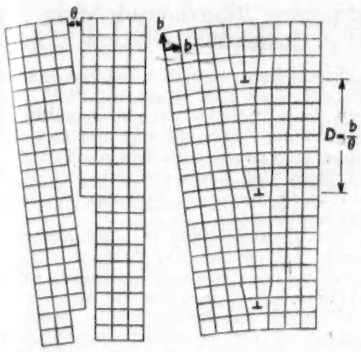
go back to their original positions. The formation of sessile dislocations gives, I think, the best explanation of this. After all, in these localised regions where the internal stress is high, it is most probable that slip on more than one set of planes will occur, so there is ample opportunity for sessile dislocation to form.

A fairly definite model of strain-hardening at low temperatures can then be given. As the stress is increased, slip spreads out from certain points in the crystal, which we call Frank-Read sources. If it can spread right across a single crystal, little or no hardening will occur. If, on the other hand, slip is stopped by a grain boundary or a " sessile " dislocation, an intense centre of internal strain is formed there. This is locked in position by the formation of further sessile dislocations. The random strains so formed within the material are directly responsible for work-hardening.

Thermal Softening or Recovery

I would like now to say a few words about the nature of thermal softening or recovery—the softening of a work-hardened metal that occurs *before* recrystallisation begins. The clue to our understanding of this is provided by recent studies of the phenomenon called polygonisation (Cahn 1951, Guiner and Tennevin 1951, Crussard

† A detailed discussion is given by Mott (1952).



a Two grains with a common crystal axis. *b* Method of joining, and dislocation model.

Fig. 12—Boundary Between Two Polygonised Regions showing how the Boundary is Formed of Dislocations

and others 1951). Briefly, the nature of this phenomenon is as follows :

When a metal crystal is bent, and then held for some time at a sufficiently high temperature, it forms blocks—which are relatively unstrained—separated by boundaries as in Fig. 10. Now this cannot occur by a process at all similar to slip. To see this, let us consider the arrangement of atoms in the bent crystal. It will contain a number of the groups of dislocations already discussed, which will be found at the extremities of slipped planes which terminate in the material. The form of one of these is illustrated in Fig. 11(*a*). After polygonisation, however, the dislocations will be arranged as in Fig. 12, a configuration of lower energy. But they can reach this configuration only by moving out of their slip planes. And this they can do only by absorbing or giving off vacant lattice sites. Polygonisation, then, involves the formation of vacant lattice sites and their movement through the lattice, and its activation energy will be the same as for self-diffusion.

Thermal recovery, we believe, is a process of just this type. The hardness of a work-hardened material is due to groups of dislocations of the type illustrated in Fig. 11(*a*). The material will soften if they separate from each other, as in Fig. 11(*b*). This they can do through the movement of vacancies, so softening can occur when self-diffusion is possible.

Symposium on Aluminium Alloy Castings

A SYMPOSIUM on aluminium alloy casting, sponsored by the Aluminium Development Association, was held on Thursday, November 6th, at the Queen's Hotel, Birmingham, and also at Claridges Hotel, London, on Tuesday, November 11th. Forming part of the symposium was an exhibition of aluminium alloy castings which was also on view in Birmingham on Friday, November 7th, and at the Association's headquarters at 33, Grosvenor Street, London, W.1, on Wednesday, November 12th. The fostering of an exchange of information and ideas between the users, the foundry industry and the producers of aluminium casting alloys was the purpose of the symposium. The main consideration, in selecting the subjects for the papers and the examples for the exhibition, was the question of design problems and foundry technique as they affect and are affected by the requirements of users. At the London meeting, Mr. G. Herrington, the president of the Association, and Mr. R. D. Hamer, the vice-president, received the guests before the presentation of the papers. During the morning session, at which the president took the chair, five papers were reviewed :—" An Introduction to Aluminium Alloy Castings," by Mr. D. C. G. Lees ; " The Importance of Standards for Aluminium Alloy Castings," by Mr. E. Elliot and Mr. F. H. Smith ; " A Survey of Some Researches on Aluminium Founding," by Mr. W. A. Baker ; " Developments in Finishing Aluminium Castings," by Mr. A. P. Fenn ; and " The Assembly of Aluminium Castings by Welding," by Mr. H. W. Keeble. At luncheon, the president, after formally welcoming the guests, commented upon the achievements of the aluminium industry during its comparatively short life of seventy years and mentioned that the foundry section produced some 70,000 tons of castings per annum, which represented approximately one-quarter of the total of this country's semi-finished aluminium products. He went on to state that the industry welcomed the opinions of users as being of help in the solution of problems. On the question of future supplies, he said that present plans envisaged the availability of adequate supplies within the next few years. The symposium was continued in the afternoon, when the following papers were reviewed :—" Development in Foundry Practice," by Mr. E. Player ; " Some Interesting Aluminium Alloy Castings," by Mr. A. Eyden, Mr. G. L. Turner, Mr. J. W. James, Mr. A. Ratcliffe, Mr. J. Caven and Mr. H. C. Cross ; " The Design of Aluminium Alloy Castings," by Mr. L. Fletcher ; and " The Future Outlook for Aluminium Castings," by Mr. L. R. Carr. After the conclusion of the symposium, three films were shown at the headquarters of the Aluminium Development Association, 33, Grosvenor Street, where there was also an exhibition containing about 150 castings, produced by various methods and in a number of alloys, which demonstrated the application of aluminium castings to general engineering, textile machinery, mining equipment and many other industries.

The nine papers dealing with casting design and foundry technique, presented at the symposium, are summarised below.

The first paper in the morning was " An Introduction to Aluminium Alloy Castings," by D. C. G. Lees, M.A., which opens with a brief historical survey of casting as a method of manufacture. Fabricated welded plate assemblies are mentioned as being competitive with casting, but not for small work, and also the scope existing for the welding of castings to form assemblies and of welding cast to wrought aluminium alloys. Increased knowledge of the mode of solidification and the use of X-ray inspection has made for mechanical reliability of castings. The value of various alloying elements in strengthening the metal to give a good strength/weight ratio is noted, and also the attempts to increase Young's modulus. There are short references to the various properties of aluminium and some general notes upon the properties and production of aluminium castings.

" The Importance of Standards for Aluminium Alloy Castings," by E. Elliot and F. H. Smith, was the title of the second paper. This traces the development of the alloys and emphasises that each is suitable for certain purposes, but not necessarily for all-round application. The various stages in the preparation of a British Standard are briefly outlined and reference is made to the early and present-day standards for aluminium alloy ingots and castings, including an explanation of the system of nomenclature in B.S. 1490, together with a note upon standards in preparation. The advantages to be gained by using standards are discussed and the dangers inherent in the employment of near-specification alloys recounted, together with examples of the use of castings in such material. After making one or two points concerning the selection of alloys, the paper goes on to deal with the various methods of inspection of ingots, including analysis by spectrograph and polarograph, and also the test employed in the inspection of castings.

W. A. Baker, B.Sc., gave the next paper, " A Survey of Some Researches on Aluminium Founding," which deals with basic technical problems in making aluminium alloy castings, namely, those arising from the characteristics of the molten metal and those arising from characteristics of the mould. Under the first heading, the flowing power, which is determined by the heat content of the metal, is discussed and illustrated graphically, fluidity run being plotted to a base of superheat. The relationship between volume and temperature is stated to be the cause of the difficulties in casting. The temperature gradient, as related to the mechanism of solidification, is demonstrated by a diagram of unidirectional solidification of a casting having a steep temperature gradient, and another showing isotherms in a sand-cast plate. With regard to the mechanism of hot tearing and the formation of porosity, the paper states that these are likely to occur when the freezing range is long and when most of the solid separates in the upper part of the range. Casting behaviour, strength and elongation are greatly influenced by grain size and refinement affects shrinkage porosity and minimises the tendency to hot tearing. The question of gas absorption is generally discussed, together with the removal of hydrogen by its diffusion into an inert atmosphere. Large amounts of gas produce gross pinhole porosity, but small amounts of gas may be advantageous for certain castings. Special equipment, which is available for industrial use, for detecting gas before the metal is poured, is illustrated, and it is noted that alloys containing magnesium are prone to react with steam in the mould atmosphere.

In discussing the solidification of castings, the effect of the overall rate of freezing is considered and linked with the use of moulding materials with varying thermal properties for castings of different cross-section. Graphical illustrations and tabular statements show the effect of the rate of freezing. It is observed that the rate of solidification in metal moulds can be controlled, but not in those of refractory materials.

The fourth paper presented, " Developments in Finishing Aluminium Castings," was given by A. P. Fenn, in which recent developments are surveyed under six main headings. Following a note upon mechanical finishes, there is a review of paint finishes, in which developments such as the acid chromate dip and wash primers are mentioned. The introduction of new organic resins have helped in the progress of stoving enamels, and bituminous paints have been developed to take colour. Research during recent years has resulted in an improvement of plating processes, and the zincate pre-plating method is mentioned, together with the Vogt process. With regard to anodising, it is suggested that correct foundry technique should produce a good surface and that an alloy, suitable for casting and anodising should be developed. Highly reflective surfaces are produced by electrolytic processes and bright chemical dips, but electro-polishing has not been applied generally to castings. Vitreous enamelling, it is stated, is not a commercial proposition in this country, and the essential characteristics of the finish are recorded, particularly the low firing temperature and the coefficient of thermal expansion. Among the hard surfacing processes, chromium plating has reached a stage where engineering components can be treated to provide a hard surface and a thickness of not less than 0·001in is recommended. A hard surface film has been produced also by a treatment which forms an anodic film 0·01in thick, but it can only be applied to certain alloys.

The final paper of the morning session was given by H. W. Keeble, and entitled " The Assembly of Aluminium Components by Welding." The paper suggests that complex castings should be made up of simpler units assembled by welding, to save time and reduce cost, and the inert-gas shielded arc welding process is recommended. In designing the small castings, welding requirements must be considered and alloys in order of preference for welding are

noted, while scratch brushing or washing with 10 per cent nitric acid solution is recommended as part of edge preparation. The welding of castings to sheet or plate assemblies is treated, several examples of this form of assembly being illustrated.

The first paper of the afternoon session was "Recent Developments in Aluminium Foundry Practice," by E. Player. The subject is broadly dealt with in three sections, the first being concerned with moulding methods. The increasing complexity of castings has called for accurate control of the moulding medium, so that natural sand has been replaced by a synthetic sand, the comparative properties of which are given. Precision plaster moulds are referred to, and the plaster process is described and illustrated and, as an example of the accuracy attained, the limits of ±0·005in on a diameter of 26in is quoted. The deciding factors in choosing the permanent mould casting process are given and it is noted that for large outputs and for large dies, mechanical and power-aided die movements are being increasingly used, while thin sections are obtained by use of the vacuum die process. Diagrams illustrate pressure die casting systems, and some design data are listed. In the second part of the paper, foundry equipment is touched upon, including notes upon melting, moulding and core making, inspection by X-ray, control of gas content and the effect of grain refinement. The paper concludes with a short reference to alloy developments.

In the next paper, under the overall title of "Some Interesting Aluminium Alloy Castings," four examples of light-alloy foundry work are described and illustrated. An aluminium automobile cylinder block, produced by gravity die-casting, is described by A. Eyden, followed by an account of unusual examples of pattern and die construction by G. L. Turner, B.Sc., J. W. James and A. Ratcliffe. The third section of the paper, given by J. Caven, deals with aluminium alloy castings made with inserts "cast in," and the fourth example, the base and main structure of a dental stand, is described by H. C. Cross.

The third paper was "The Design of Aluminium Alloy Castings," by L. Fletcher. In it reference to the three basic casting methods is followed by some notes upon the aluminium alloys, accompanied by a table giving the casting characteristics and general properties of the alloys as a general guide for selection purposes. Problems in casting aluminium as they affect design are discussed, including those related to the low density of the metal, shallow temperature gradients and the freezing range. Many points concerned with the design of a casting are illustrated with diagrams and collaboration between user and producer is advocated.

The final paper of the symposium was "The Future Outlook for Aluminium Castings," by L. R. Carr, M.A., M.P. The present position of the industry is generally reviewed, with brief references to research, foundry technique, properties of the alloys, quality control, finishes and assembly methods. With regard to the future, a table giving the tonnage of castings produced during recent years indicates production trends, and another table, which records an analysis of end uses of aluminium alloy castings, serves to show the markets in which application may be expanded. Their influence on a number of markets, including road transport, railways, shipping, building, general engineering, agriculture, mining and electrical is reviewed.

The Salanfe Hydro-Electric Scheme, Switzerland

WORKS for the construction of the Salanfe hydro-electric scheme in Western Switzerland are now making good progress. The main feature of the plant is a gravity dam, the overall length at the crest of which will be about 2000ft. The volume of concrete placed on the contract will exceed 300,000 cubic yards. The dam, whose maximum height above foundation level is 170ft, is being built in forty-two blocks, about 46ft wide, with joints between them. For inspection and maintenance there are galleries 6½ft wide and 8ft high, placed at various levels. The dam is provided with a spillway. An inclined gallery, about 2100ft long and 6½ft in diameter, connects the upper section of the penstock with the intake at the dam. The steel penstock is entirely welded; its overall length amounts to 15,000ft and its weight to 3100 tons. The power-house is an underground hall, 194ft long, 50ft wide and 58ft high, with three horizontal Pelton wheel turbo-alternator sets of 47,500 h.p. installed.

Steam Air Heaters for Marine Water-Tube Boilers

A PAPER entitled "Steam Air Heaters for Marine Water-Tube Boilers" was read before the Institute of Marine Engineers by W. S. Glass on Tuesday, November 11th, and is summarised below.

It is mentioned that in an earlier paper, which gave an historical review of air preheating practice, a case was made out for the regenerative heater, and it is of interest that the first patent taken out by James Howden was for a steam air preheater using air, heated as the cooling medium in a condenser, for combustion purposes.

Air heaters with vertical tubes have been known to require retubing within two years, and sooty deposit, left on the top tube plate, combined with moisture, corrodes the tube ends. With the dew point lying between 120 deg. and 320 deg. Fah., depending upon conditions, it is difficult to maintain the heater at a temperature which avoids this critical point. However, by using a by-pass it is possible to prevent the gases reaching the dew point, but the by-pass is usually inconveniently placed and is seldom a 100 per cent by-pass, being generally about 30 per cent of the cross sectional area of the main ducting. This area is not adequate for manœuvring, and recently a thermostatically controlled 100 per cent by-pass has been produced, together with a reheat arrangement in which part of the air from the heater is returned to the fan intake to warm the heater air supply. This system does not preclude moisture from forming, since the temperature of the air inlet tubes measured 164 deg. to 189 deg. Fah.

Horizontal air heaters give five to six years' service, but are more liable to fires, and regenerative heaters are easier to keep clean.

The paper states that for steam conditions of 600 lb. per square inch and 850 deg. Fah. superheat a higher boiler efficiency than is obtained with a gas air preheater and three-stage feed heating is necessary. In an American paper, read in 1949, three alternatives were given, namely, gas air heater with an economiser and three-stage feed heating, steam air heater with an economiser and two l.p. feed heaters and a gas air heater and three-stage feed heating, the thermal advantage lying with the first alternative. In this, however, efficiency is lost, due to soot deposits, and a case is made out for the second alternative.

The overall heat transfer coefficient in a tubular gas air heater, it is stated, is low, being about 4 B.Th.U. per square foot per degree Fah. per hour, while in the steam air heater the overall coefficient is approximately eight. In the latter the addition of metal gills and the use of small-diameter tubes for the steam flow allow a compact design. In American-built 28,000-ton tankers, using high-pressure steam, steam air heaters have given three years' trouble-free service, and particulars of steam conditions are given, together with a formula to give the steam required for a steam air heater.

For a turbine installation using steam at 525 lb. per square inch and 850 deg. Fah. six alternative arrangements of heat recovery are considered and the basic figures for each arrangement are given in tabular form. Two of the arrangements are illustrated diagrammatically. Photographs show a steam air heater, in production in this country, which has cold-drawn seamless steel tubes 1in diameter by 10 S.W.G., with 3in by 2in by 18 S.W.G. steel gills, and costs approximately half that of a gas air heater.

Structural Behaviour of Main Engine Bedplate in a Cargo Ship

ON November 14th, A. J. Johnson, B.Sc.(Eng.), A.C.G.I., and J. E. Richards, Ph.D., Wh.Sc., read a paper, entitled "The Structural Behaviour of the Main Engine Seatings and Bedplate in a Cargo Ship under Static Bending Tests," before the North-East Coast Institution of Engineers and Shipbuilders. A summary of the paper appears below.

This paper describes the experimental work carried out on the S.S. "Ocean Vulcan," on behalf of the British Shipbuilding Research Association, and is concerned with the investigations into the flexure of the bedplate and seatings of the triple-expansion steam engine while the ship was subjected to static bending tests. Although present interest is mainly with oil engines, nevertheless the opportunity was taken to obtain data concerning the structural characteristics of bedplates and seatings in relation to the ship's structural strength and to gain experience and develop techniques for this form of investigation. Dynamic engine loads are not considered.

A brief historical survey is given of publications dealing with the subject, including papers by Dr. J. Montgomerie and Dr. S. F. Dorey, and a number of drawings serve to give information concerning the details of the engine bedplate seatings and hull structure. Instrumentation is dealt with next, together with testing technique. Dial gauges were used to measure deflections over large distances, while electric resistance and acoustic strain gauges were used for the shorter lengtns and the arrangement of the gauges is illustrated. The ship was subjected to eleven different conditions of loading, to give pre-determined bending moments for which gauge readings were recorded. The results for the extreme hogging and sagging conditions are shown graphically, while tabular statements give the values at each loading in way of the bedplate.

An examination of the results of plotting the central deflection of the bedplate and the deflection deduced by formula, against bending moment, shows that the actual deflection is approximately twice the calculated flexure of the ship girder over the same length. Longitudinal deflections of the bedplate show that there is a "virtual" neutral axis of bending about 3ft above the tank top as against the 11·5ft of the ship girder, and so illustrate local bending effect. Results from instruments on the bedplate and tank top indicate that sliding movement between bedplate and seating is negligible.

A section of the paper analyses local bending and, by means of a mathematical solution of an analogous problem, a composite beam, end-loaded and having uniform lateral elastic restraint, it is shown that the large deflection of the bedplate is due to local changes of section in way of the engine seating. From the actual measured relationship between total bending moment and bedplate deflection, the vertical deflections under service conditions are calculated and, assuming true alignment in the light condition, the central deflection of the bedplate in the loaded condition is estimated to be 0·010in sag in still water. To this figure must be superimposed the deflections set up in the ship during its passage through a wave of standard length and height, so that the actual central deflections will be from 0·0037in hog to 0·0237in sag. At the higher bending moments, there is a marked departure from the mean slope of the bending moment-deflection curve in the hogging condition, so that bedplate deflections may be higher than those given.

Strains and stresses are discussed and it is noted that there will be an average longitudinal stress of about 2 tons per square inch set up in the bedplate due to the flexing of the ship in the conditions described. The effect of the cylinder block and supporting columns upon the bedplate deflection is stated to be very small and there are notes upon thermal effects, crankshaft deflections, and bearing pressures. The most serious effects of flexure of the bedplate are high pressures set up in some main bearings, resulting in unequal wear and high crankshaft bendng stresses.

The U.S. National Metal Congress and Exposition

(By our American Correspondent)

THE 34th National Metal Congress and Exposition was held in Philadelphia, Pennsylvania, from October 20th to 24th. As in previous years, it was sponsored by the American Society for Metals, the American Welding Society, the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, and the Society for Non-Destructive Testing. The purpose of the "Metal Show" is to bring together the experience, the knowledge and the means for a more effective use of metals in the making of products for both civilian and military use.

The National Metal Exposition

Some 400 companies engaged in either the production, treatment or fabrication of metals gave displays and demonstrations of their products or services at the exhibition, which was held in the Philadelphia Convention Halls. Jet engine and gas turbine development gave great interest to the new heat-resistant materials on display.

An outstanding development in this field is "Kentanium," a heat-resistant titanium alloy offered in various grades by Kennametal Incorporated, of Latrobe, Pennsylvania. The material has titanium carbide as its chief ingredient, with nickel as the primary auxiliary metal. Most compositions contain a small percentage of other refractory metal carbides, such as tantalum and columbium, which have higher melting points than titanium carbide. A small quantity of these supplementary ingredients has been found to be effective in making the compositions highly resistant to oxidation. "Kentanium" is not melted and cast, but is made by methods of powder metallurgy which produce a material of remarkable uniformity and freedom from the effects of segregation and grain size variation. A number of grades of the material have been developed to satisfy the varied requirements of temperature stress, oxidation resistance, thermal shock resistance, hardness, &c. For example, an application may involve severe oxidation conditions, maximum thermal shock, and need for high strength. Again, there may be cases in which one or more of these requirements are less rigid. The amount of auxiliary metal influences the thermal conductivity, tendency toward plastic flow, and strength. The lower its content the lower is the tendency for plastic flow at any given temperature; at the same time, thermal conductivity and strength are reduced so that the resistance to thermal and mechanical shock is lower. Some physical and mechanical properties of the various grades of "Kentanium" are tabulated herewith.

Properties of "Kentanium"

"Kentanium" grade	Density, g/c.c.	Hardness (Rockwell "A")	Modulus of rupture strength, lb/sq in	Tensile strength lb/sq in	Modulus of elasticity, lb/sq in
K151	5·5	89·5	190,000	—	—
K151A	5·8	89·5	175,000	—	57,000,000
K151B	5·7	89·5	150,000	95,000	49,000,000
K152A	6·2	84·5	150,000	—	—
K152B	6·0	85·0	210,000	100,000	47,000,000
K153B	6·3	82·8	185,000	110,000	41,000,000
K161B	5·7	90·2	165,000	76,000	60,000,000
K162B	6·0	89·0	230,000	115,000	59,000,000
K163B	6·2	87·4	210,000	130,000	56,000,000

Rods, tubes, and flats of the material are extruded, and simple shapes moulded, while the more intricate forms are machined from pressed slugs. If greater dimensional accuracy is demanded, the required tolerance or finish can be attained by grinding with diamond wheels after the forms are sintered. Some of the most promising and important applications which the material has found to date include nozzle vanes and blades for jet engines, valves, valve seats and guides for reciprocating engines, balls for hot hardness testing, anvils for spot welding, inserts for hot die forming, hot extrusion die inserts for light metals and brass, bushings, thermo-couple protection tubes, flame tubes, and numerous other forms where strength at temperature, wear resistance and corrosion resistance are required.

An interesting automatic pouring unit for the production of aluminium die castings was shown by the Ajax Engineering Corporation, of Trenton, New Jersey. The unit is known as the "Ajaxomatic" installation and is designed to discharge directly into the cold chamber of most available American die casting machines. Molten metal is taken from a point considerably below the surface of the melt, eliminating any chance of pouring surface oxides or scum into the casting. The equipment acts as a combined holding furnace and automatic pouring unit. The temperature and alloy composition of the melt are maintained accurately by the Ajax-Tama-Wyatt inductor, which is based on the principle of gentle electro-magnetic stirring. It should be understood that the unit is not a melting furnace. It is supplied with batches of molten aluminium from separate melting furnaces at regular intervals, thus fitting into the practice of most American die casting plants where conventional hand ladling furnaces are in use. The pouring unit can also be used for zinc alloys, and it is hoped that it will point the way to the economic use of cold chamber machines for these materials.

Recently, the first order was placed in America for a Junghans-Rossi continuous steel casting machine to be used in the commercial production of 7½in by 2½in by 16ft long alloy steel slabs for subsequent conversion into strip. This unit is being designed and built for Atlas Steels, Ltd, of Welland, Ontario, by the Freyn Engineering Department of the Koppers Company, Chicago, Illinois, the American licensees of the Rossi continuous casting process. Considerable attention was therefore attracted by a scale model of this machine, which was exhibited by the Koppers Company. As continuous casting of slabs virtually eliminates ingot casting and stripping plant, soaking pits and blooming mill operations, it is viewed with growing interest by a number of American steel producers, and the placing of contracts for additional installations is expected.

One of the most decided trends to be observed at this year's exhibition in the field of arc welding equipment is the growing popularity of d.c. rectifier welding sets compared with motor generator sets. To-day, most American manufacturers of arc welding sets offer users both an a.c. transformer welding set and a d.c. set employing a similar transformer design in conjunction with a selenium rectifier. Both a.c. and d.c. units tend to be of almost identical external appearance and size and are equipped with either manual cranking or motorised welding current control. The range of selenium rectifier d.c. welding sets introduced by the Miller Electric Manufacturing Company, of Appleton, Wisconsin, is of particular interest, as it makes use of the principle of the magnetic amplifier and gives a high short-circuiting current and a pulsating direct current. The transformer design employed in these sets results in a rectangular unit with a very low centre of gravity. The weights of the sets are some 30 to 50 per cent less than those of equivalent motor generator sets. Since there are no moving parts, except the cooling fan motor, the sets can be expected to require comparatively little maintenance. Current control is entirely by electrical means incorporated directly into the transformer; there are no movable coils or movable core reactors and no external saturable reactors, all current-carrying parts remaining fixed at all times. Remote control can be effected by connecting the three wires of a remote control unit to a terminal board provided for this purpose on the welding set. The complete current range of the machine is obtained in two steps by plugging the electrode lead into one of two receptacles. Either straight or reverse polarity is available to the operator, and it is stated that accidental polarity reversal cannot occur with these machines. Because the selenium rectifier d.c. welding sets lend themselves readily to specialised applications, several control units are available, which are housed in a cabinet that may be attached to the side of the sets proper. These units provide for the control of argon or helium shielding gas and cooling water flow as used in the inert gas arc welding process. Adjustable time delay is provided so that the gas and water flow is continued for a definite time after the power has been shut off. A primary contactor and ½kVA control transformer are included and continuous fan operation is provided. A special attachment is available providing high-frequency current to initiate the arc. A time delay relay is used so that the high frequency is shut off after the arc has been started.

It was announced at the exhibition that automatic submerged arc welding equipment is to be manufactured by the A. O. Smith Corporation, of Milwaukee, Wisconsin. This firm has developed a universal automatic welding head having a maximum a.c. or d.c. rating of 1500A and making use of a bare electrode wire and a conventional welding flux. The unit has been undergoing works tests and is expected to be in commerical production by the end of this year. Multiple electrode automatic submerged arc welding heads have now been developed by both the Linde Air Products Company, of New York, and the Lincoln Electric Company, of Cleveland, Ohio, and were demonstrated for the first time at the exhibition. By using two or more electrodes in the tandem or transverse position it is possible to obtain unusually high welding speeds, and a control of the weld shape not obtainable with a single electrode. As the welding power is applied to two or more electrodes in the same welding zone, higher currents can be used without producing excessive penetration. Furthermore, magnetic reactions between the electrodes can be regulated to improve the weld shape by controlling the direction of the arcs. Frequently, alternating and direct currents are used simultaneously, and current for multiple electrode welding can be obtained from various connections of standard transformer or motor generator sets.

Another display at the stand of the Linde Air Products Company concerned the new "Flame-Plating" process, an interesting method of applying thin metallic coatings, such as tungsten carbide, to metal parts. The deposit is made in the form of a hard, wear-resistant coating applied in thicknesses ranging from 0·0005in to 0·020in. It is claimed that such coatings are unmatched, for certain applications, in their ability to resist frictional and abrasive wear. The bond between the base metal and the coating is mechanical—it is not a welded bond. Because of the way in which the coating is applied, there is no mixing of the coating with the base metal. One of the major advantages of this process is that the temperature of the base piece does not exceed 400 deg. Fah. during the plating operation, even when tungsten carbide is being deposited. This practically eliminates any possibility of a change in the properties of the base metal, and reduces to a minimum the chance of warping. For this reason the process is well suited for precision parts where only extremely small tolerances are allowable. Several coating materials have been and are being tested for use with the process. Much of the initial research and development has been done with tungsten carbide, and all of the present commercial applications use this material, which differs from sintered tungsten carbide and is composed of tungsten, carbon and 8 per cent cobalt in complex forms.

The hardness of the resulting tungsten carbide coatings averages about 1350 Vickers pyramid number. Actually, it is believed that the particles making up a flame-plated coating are harder than indicated by the Vickers test. The difference between actual (particle) hardness and apparent (coating) hardness is due to the kind of bond between particles. This bond, though it lowers the apparent hardness, has been found to improve the wear resistance. The modulus of elasticity of flame-plated tungsten carbide is surprisingly low, being only 15,000,000 lb per square inch, compared with 85,000,000 lb to 90,000,000 lb per square inch for sintered

tungsten carbide. This extreme difference in stress-strain relationship is also attributed to the particular bond between the individual particles in a coating. Because of this bond between individual particles, the low modulus of elasticity and the thinness of the coating, the stresses induced in flame-plated tungsten carbide by a given temperature differential are low. Thermal shock at a moderate rate has little or no effect on thin coatings. The most satisfactory resistance has been found to be obtained with thicknesses not greater than 0·003in after grinding. Although a tungsten carbide coating has the inherent brittleness of tungsten carbide in any form, the coating can absorb a moderate amount of deformation. For maximum mechanical shock resistance the coating thickness should not exceed 0·003in after finish grinding. Any shock or impact that causes permanent distortion of the base piece impairs the coatings regardless of coating thickness.

Tungsten carbide can be deposited on almost any base metal by flame plating. Steels of all types, cast iron, aluminium, copper, brass, bronze, titanium, and magnesium have all been coated successfully by this process. In the majority of applications tested to date, parts coated with tungsten carbide have shown wear resistance superior to cast alloys, hard chromium plating and tool steels. Flame-plated parts have been found to have all of the desirable wear properties of sintered tungsten carbide, and in addition have a lower modulus of elasticity and greater resistance to impact and thermal shock.

Among the displays shown by the Air Reduction Company, of New York, was an initial demonstration of the firm's automatic hard facing process, which employs an automatic "Heliweld" head and a unit for feeding bulk tungsten carbide. The unit was developed because of a need for an improved method of depositing tungsten carbide hard facing material on tool joints for well drilling equipment. It is claimed that the process produces the quality of deposits obtainable with the manual oxy-acetylene method of deposition, and, with better quality, equals the production rates of other automatic arc methods of deposition. The hard facing unit, which employs an inert gas shield in conjunction with a non-consuming electrode, has been found to be particularly efficient when applied to heavy metal sections. However, its use for the deposition of tungsten carbide is limited only by the ability to position the work and the arc in the proper relationship to each other. The inert gas shielded arc melts the base metal, producing an elongated pool, and the tungsten carbide particles are poured into this pool behind the arc. The rate of particle feed from the vibratory hopper is electrically controlled with a high degree of accuracy, resulting in minimum particle solution, efficient particle distribution and a narrow heat-affected zone. Tests have shown that the abrasion resistance of deposits made by this process is considerably greater than that attainable with other arc methods.

An important development in the field of high-purity metals which are finding an increasing demand in the electrical and electronic industries is the formation of the Vacuum Metals Corporation, as a subsidiary company of the National Research Corporation, of Cambridge, Massachusetts. The company is specialising in the production of high-purity metals by melting and purifying commercial quality metals in high-frequency induction furnaces under high vacuum. The purified metal is cast into ingots under vacuum and is processed into fabricated shapes under carefully controlled conditions. At the present time the metals available include the following :—"Cuprovac," a gas-free, high-purity electrolytic copper ; "Ferrovac-R," a gas free, high-purity carbonyl iron ; "Ferrovac," a gas-free, high-purity electrolytic iron ; and "Nivac," a gas-free, high-purity nickel. The degree of purity obtainable is illustrated by the chemical composition limits, shown in the table below, guaranteed with respect to the company's "Cuprovac" metal.

The metal has remarkable freedom from oxide inclusions, dissolved and entrapped gases, and high vapour pressure elements, such as phosphorus, sulphur and bismuth. It has a high ductility and electrical conductivity. Its rate of hardening is low and its corrosion resistance is improved. The metal is already being used by the electrical and electronics industries for components such as magnetrons, klystrons and transmitting valves and for magnet wire. The use of high-purity metal has been found to reduce exhaust times and to prolong valve life by minimising pressure build-up, which contributes to a longer performance life. The absence of

Purity of "Cuprovac"

	Less than, per cent
Nitrogen	0·0005
Oxygen	0·0015
Hydrogen	0·0001
Antimony	0·001
Arsenic	0·001
Bismuth	0·0001
Iron	0·002
Lead	0·0001
Nickel	0·0005
Phosphorus	0·0001
Selenium	0·00005
Silver	0·001
Sulphur	0·0001
Tellerium	0·00005
Tin	0·001
Zinc	0·0007
Silicon	0·001

gaseous and other chemical impurities also minimises undesirable reactions with other materials in glass to metals seals, and in composite soldered valve assemblies.

In the field of non-destructive testing the inaugural demonstration by the X-ray department of the General Electric Company, Milwaukee, Wisconsin, of its "Resotron 250" portable industrial X-ray unit caused considerable attention. The machine, which has a continuous rating of 2mA to 10mA at 75kV to 250kV peak, is less than half the size and less than one-eighth the weight of a conventional 250kV unit. The mobile tube head is capable of penetrating steel up to 3½in in thickness ; it is less than 15in in diameter and 44in long and weighs only 150 lb. For transport, a two-wheel trailer is provided, which has been designed to carry the power supply unit, the control unit, the water cooler, the cable reels, as well as the tube head. The total weight of the loaded trailer is 2600 lb.

At the stand of Sperry Products, Incorporated, of Danbury, Connecticut, an interesting new water immersion technique of ultrasonic testing was demonstrated. The primary advantage of this new technique is the ability to test odd-shaped or rough-surfaced parts without the necessity of extensive surface conditioning or the use of specially shaped searching units. When the wave passes from the crystal to the material to be tested through air gaps caused by rough interfaces, the diffraction may be so violent as to set up "pips" on the oscilloscope that could appear as a false signal. In the past this frequently made it necessary to grind and polish flat surfaces on parts to be tested to avoid violent reflections of rays passing through the air. A film of oil or grease was then applied to make the transition easier. Finally, the technique of immersing both the test material and the crystal scanner in water was found to be the best way to cut down interference "hash."

A number of automatic immersion testing machines have now been developed by an American aircraft manufacturer to handle the task of ultrasonically testing aluminium plates, forgings and bars intended for production use. The new method proved so successful that a considerable saving in man-hours of testing has been effected, and at a recent conference of representatives of the Aluminium Company of America and engineers of six airframe manufacturers, agreement was reached for the adoption of uniform ultrasonic immersion testing procedures and a set of standard calibration blocks to classify types of flaws in material being tested.

According to the company, immersion testing facilitates : (1) a faster inspection rate ; (2) the coverage of some areas which cannot be covered by contact scanning ; and (3) moving the crystal through various angles in relation to a specific area on the part to be tested, so that the extent of the discontinuity can be better assessed.

The National Metal Congress

The technical sessions of this year's National Metal Congress arranged by the American Society for Metals were held in the ballroom of the Benjamin Franklin Hotel and the ballroom of the Convention Hall. They included a week-end seminar on "Modern Research Techniques in Physical Metallurgy" and three courses of educational evening lectures dealing respectively with "Behaviour of Metals at Low Temperatures," "Gases in Metals," and "Metallurgical Tools for Alloy Conservation and Increased Production." The day programme of the Congress offered sessions on the subjects of "Creep Rupture and Recrystallisation," "High Temperature Phases," "Phase Transformation," "Hardenability," "Mechanical Properties," "Temper Brittleness," and "Elevated Temperature Properties." This year's Campbell Memorial Lecture was delivered by Dr. C. S. Smith, director of the Institute for the Study of Metals at the University of Chicago, and was entitled "Microstructure."

The social highlight of the Congress was the annual dinner of the American Society for Metals, held in the grand ballroom of the Benjamin Franklin Hotel on Thursday, October 23rd, and presided over by Professor John Chipman, of the Massachusetts Institute of Technology. The A.S.M. Gold Medal was presented to Dr. R. F. Mehl, Head of the Department of Metallurgy of the Carnegie Institute of Technology ; and the A.S.M. Medal for the Advancement of Research to Mr. C. F. Craig, president of the American Telephone and Telegraph Company. Honorary membership in the Society was conferred upon Dr. C. H. Desch, past-president of the Iron and Steel Institute, who was unable to attend the Congress on account of illness.

Indian Engineering News

(By our Indian Correspondent)

Five-Year Plan for Kashmir

Details have now been announced of the Rs.13 crore (£10 million) plan for the State of Jammu and Kashmir to run concurrently with India's Five-Year Plan. The state's contribution will amount to Rs.3 crores (£2·25 million), the balance being met by the Union Government. India's own plan was published last year in draft form to elicit comment from the public and the revised plan is expected to be announced by the end of October. The delay in the publication of the Kashmir Plan is ascribed to the "prevalence of uncertain political conditions, during the last few years," which, according to a spokesman of the Government, "have only just begun to straighten themselves out." The plan represents the first real attempt at rational development of the natural resources of a state which, economically and socially, is one of the most backward in India. The state's original plan was to cost over Rs.22 crores but has been reduced to the present sum ; the rest of the plan will be carried over to succeeding years.

Irrigation and power projects, which occupy the foremost place in the plan, will account for about Rs.4 crores. The estimated expenditure on the Banihal tunnel providing an all-weather link for the first time between the provinces of Jammu and Kashmir, is expected to be about Rs.3 crores. Roads come next in importance with an allocation of Rs.1·5 crores. The remaining projects, including cottage industries (Rs.40 lakhs), soil conservation (Rs.10 lakhs), community projects (Rs.30 lakhs), veterinary services (Rs.15 lakhs), and tourist industry will absorb the balance of Rs.4·5 crores.

Irrigation and Power.—The projected canals, will irrigate 58,000 acres of land. Among the more important of these are the Pratap canal, serving the province of Jaramu, the Kharbatang canal irrigating a portion of Ladakh district, and the Vishow and Rameshi canals irrigating about 10,000 acres in the fertile Kashmir valley. Irrigation works in progress include the Kishtwar, the Zainpore, the Sumbal, the Udhampur, the Koil and the Martand canals. All these projects are individually small but, together, they will promote the prosperity of the two provinces as well as Ladakh district.

Srinagar, the capital of the state, has recently been growing very rapidly and the small 4000kW power station at Mahura, built about 45 years

ago, is no longer capable of satisfying the increased demand both from the population and the industrial establishments. The new power project in the Sind Valley scheme on which work is already in progress, is designed to meet the maximum demand of 30,000kW in its final stage, the first stage having half the maximum installed capacity. This project is expected to ensure electric supply to the capital as well as adjoining areas. When the new plant is ready it is proposed to use the old Mohura power station for lift irrigation on the right bank of the Jhelum River. It will also be possible to provide energy for saw mills in Baramula, about 30 miles from Srinagar, whose expansion has been delayed for want of power. For the Jammu Province it is proposed to buy power from the Jogendranagar system of Punjab (India). It will serve the towns between Pathankot and Jammu, also providing power for a large number of tube wells, both for irrigation and drinking water.

The plan also mentions the possibilities of the lignite resources of Handwara, where at present mines are being exploited to provide fuel for local factories. Investigations by foreign experts have established the possibility of extracting lignite for the production of a large number of by-products. Inadequate power supply has in the past stood in the way of the project.

Roads.—The Banihal tunnel, when completed, will end the physical segregation of Jammu and Kashmir, which are cut off from each other for four or five months during the winter, when 40ft to 50ft of snow at the mouth of Banihal Pass makes the present motor road wholly impassable. The two provinces will be united by the proposed 1½ mile long tunnel at a height of 7000ft above M.S.L. The tunnel, designed jointly by Union and state engineers, will reduce the distance between Jammu and Srinagar by about 20 miles.

The original road plan involved an expenditure of Rs.5 crores, which on the advice of the Indian Planning Commission, has been reduced to Rs.1·5 crores. Besides improvement to all existing roads, construction of 395 miles of new roads in Jammu Province and 377 miles in Kashmir has been planned. These roads will open up the hinterland of the valley, which is so rich in mineral resources and which, for want of adequate transport facilities, has so far remained unexploited.

Miscellaneous.—The development of cottage industries on which a sum of Rs.40 lakhs is proposed to be spent, includes development of carpet manufacture and tanning and dyeing in the Shalteng leather factory. The state Government will open new production centres as well as improve the present emporia. It will also spend a considerable amount of money in promoting sales in the U.K. and U.S.A. Cottage industries play a very important role in the economic life of the state and in Srinagar alone over 34,000 men, 27·8 per cent of the working population, are engaged in them.

Tourist industry, hitherto not very well organised, will also receive direct aid from the state. This will include the construction of a new fifty-six-bedroom hotel in Pahalgam, improvements to existing dak bungalows (rest houses), building of bridle paths and roads in the usual tourist areas and of new rest houses and other facilities in the new areas, such as the Plateau of Yusu, the Harbal waterfalls, and the Nil Nag and Wular lakes.

Expansion of Iron and Steel Industry

India's iron and steel industry is concentrated chiefly in the States of Bihar and West Bengal, the former having the Tata Iron and Steel Company at Jamshedpur and the latter the Steel Corporation of Bengal at Asansol. These, along with the Mysore Iron and Steel Works of Mysore and the Government Ordnance Factory at Ishapore, are the main producers of steel, their annual productive capacities being 850,000 tons (Tata), 350,000 tons (S.C.O.B.), 40,000 tons (Mysore) and 24,000 tons (Ishapore). Although the total productive capacity is 1,264,000 tons, only once, in 1943, did the actual production reach the figure of 1,166,200 tons. Since then, production has been falling, mainly in consequence of labour unrest and transport difficulties, both in connection with moving coal and other raw materials to the steel mills and despatching finished steel from the mills to the users. In 1948, just after partition and before the large development schemes had gained momentum, the apparent consumption of steel was 1,040,000 tons, of which 854,000 tons were produced in the country and 186,000 tons were imported, mainly from the U.K., the U.S. and Belgium. In the financial year 1951–52, Tata produced 799,000 tons of saleable steel compared with 644,000 tons in 1947–48. But this is hardly sufficient to meet the country's expanding needs, which are estimated to be nearer the 2·5 million tons mark. Expansion of the steel industry has, therefore, been given high priority by the Planning Commission and it was announced last week by the Ministry of Production that a delegation drawn from several interested ministries was now on its way to Washington to settle the final details with the International World Bank of Reconstruction regarding the form and terms of aid for the installation of new plants and modernisation of old ones.

Two schemes now appear to hold the field. The first relates to expansion of existing plants, for which a loan of about Rs.15 crores (£11·25 million) is being negotiated with the World Bank. The balance of about Rs.20 crores (£15,000,000) or more will come from the Equalisation Fund and the Government, which is prepared to make a substantial contribution. The Tata Iron and Steel Company at Jamshedpur has an ambitious expansion and modernisation programme, which is expected to be completed by 1956–57. The programme covers the replacement of worn out and obsolete plant as well as expansion of output and diversification of products. Of the total estimated cost of Rs.35 crores (£26·25 million), Rs.13 crores cover plant expansion and diversification and the balance of Rs.22 crores, modernisation and replacements. The main items in the programme are a new Simon Carves coke oven battery, rebuilding of blast-furnaces with daily capacity increased from 800 tons to 1000 tons per furnace, remodelling of steel melting shop with five open basic hearth furnaces of 160 tons capacity, improvement to blooming mill tables, a new skelp and strip mill, including alterations to 28in billet mill, a new tube mill in association with Stewarts and Lloyds, Ltd., improvement to calcining plants and steam and power replacements and extensions. When completed the productive capacity of the works is expected to be a little over 930,000 tons per annum. The Steel Corporation of Bengal with which is associated the Indian Iron and Steel Company, also has an expansion programme for which separate negotiations have been going on with the World Bank, which has advised amalgamation of the two firms as a first step towards expansion.

Secondly, the Government is negotiating with Etna, an international firm in which American and Japanese interests are combined, for a Rs.80 crore plant (£60,000,000), which will produce, according to the Ministry of Production, 800,000 tons of pig iron and 350,000 tons of steel. It is understood that the Government has rejected German proposals to install a plant using the Krupprenn process. This, it was found, was only suitable for low-grade iron ore. As India's ore is of a very superior quality, the Holder blast-furnace is still favoured. In anticipation of a favourable outcome of negotiations with Etna and the World Bank, the Planning Commission is stated to have made an allocation of about Rs.15 crores for the proposal. The expenditure envisaged up to 1955–56 is Rs.30 crores (£22·5 million), of which half will be provided by the Government. No decision has been made whether the plant should be in Orissa or Madhya Pradesh. The capacity of this plant, together with the expected expansion in private sector, will almost double the iron and steel supplies from domestic sources and bring India, within the next eight to ten years, nearer self-sufficiency in this the most essential of basic industrial commodities.

Navigation on the Ganga

The Government of Bihar has called a conference to discuss the report of the Expert Working Group on Inland Water Transport in Asia and the Far East, drawn up by the U.N. Economic and Social Council. Participants, discussing among other subjects the methods to implement the report, will include besides the Government representatives, officials of the steamer companies operating services and representatives of trade unions. Setting up of modern wharves, introduction of mechanically propelled boats with low draughts between 4ft to 5ft, mapping out and marking all river routes for high and low levels and skilled pilot service were some of the recommendations of the U.N. report, drawn up by Mr. Otto Popper, the E.C.A.F.E. (Economic Commission for Asia and the Far East) expert on inland navigation. In the same connection, another U.N. expert, Mr. J. J. Suri, is to set up a pilot project for the navigation of the Ganga between Buxar in Bihar and Allahabad in Uttar Pradesh. The pilot project is to study the possibilities of perennial navigation on the Ganga across a 200 mile stretch between the two points in Bihar and U.P.

The Ganga water line in Bihar is 450 miles long with no fewer than eighteen major ghats (landing stages). It is navigable for about 290 miles. Bihar rivers are navigable for about 800 miles: the Gandak (175 miles), Bagmati (180 miles), Sikrahna (110 miles) and Sone (50 miles). The Kosi is navigable in short stretches during the floods. The Ganga, the only main line of communication from early days, has a long navigational history. A band of nautical experts in the East India Company's Corps of Engineers worked through difficult days to chart the steamers' course during the early periods of British Administration. Before the railways in 1853, the Ganga was the only means of transport for passengers and merchandise between the Port of Calcutta and the hinterland of Bengal and Bihar. Engineers at one time planned navigation from Allahabad upwards on the Yamuna, right up to Kalpi. It took a month to cover the 800 mile course from Calcutta to Allahabad. Many an industry of Bihar, namely, saltpetre, indigo, opium, calico and silk, was dependent on the movement of vessels on this route.

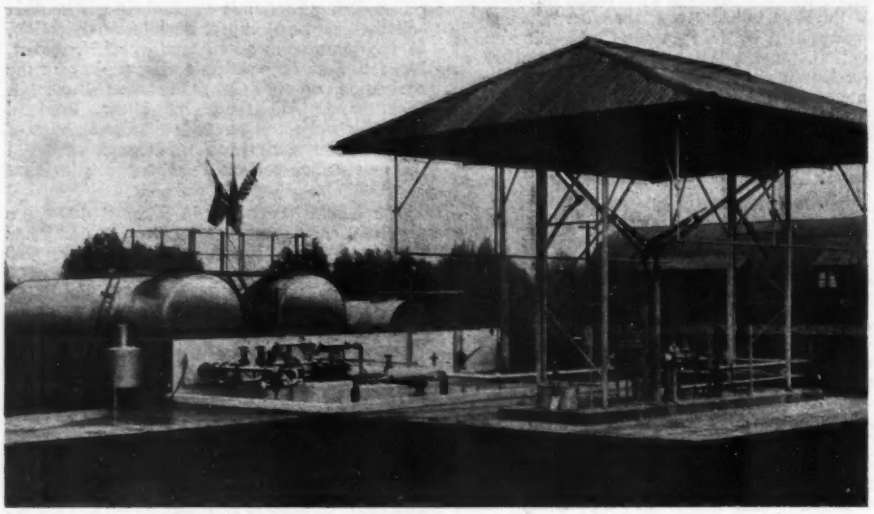
The Interstate Ganga Water Transport Board, set up by the Union Government for the control of the Ganga and the Brahmaputra, is said to have given top priority to the opening of the Buxar-Allahabad stretch in order to link with Calcutta. The Board, which works in conjunction with the Central Water and Power Commission, has five subscribing members, including the Central Government and the four states, Bihar, West Bengal, Uttar Pradesh, and Assam. The Central Water and Power Commission has already completed a survey of the Ganga and its findings support the general conclusion that navigability can be extended from Buxar to Allahabad and that a minimum depth of about 6ft is maintainable over shoals.

Books of Reference

"*Metal Industry*" *Handbook and Directory*, 1952. London: *Metal Industry*, Dorset House, Stamford Street, S.E.1.—This yearbook, which is issued only to subscribers to the journal, has been extensively revised and brought up to date. It is divided into four main sections, the first of which gives in a concise form a considerable amount of useful information covering a wide field of the general and proprietary metals and alloys, British Standard, Admiralty and D.T.D. Specifications, &c. The second section contains much useful general data and other information in table form on weights, properties, &c., of metals. Electroplating and the plant, solutions, &c., used is dealt with in the third section of the book, which concludes with a useful directory of the bodies and associations concerned with the metal industry, and a buyers' guide. As in previous years, the handbook will be found a useful work of reference by those producing, processing, marketing, and purchasing metals and alloys.

Fuel Distribution Depot

THERE has been completed recently at Botley Road, Oxford, a motor fuel distribution depot, which has been specially built for Home Counties Petroleum Products, Ltd., a new company jointly owned by the City Motor Company (Oxford), Ltd., and the Vacuum Oil Company, Ltd. This bulk supply depot will operate throughout Oxfordshire, most of Berkshire and part of Buckinghamshire and Northamptonshire, and serve the area through the medium of road tank wagons having capacities of 1200, 2400 and 3600 gallons. The equipment includes remote-controlled pumps for receiving petrol and diesel fuel, and also for loading them into delivery vehicles. By means of the open-fill system, which the Vacuum Oil Company, Ltd. has pioneered in this country, very high delivery rates are possible, a 2400-gallon tank wagon being loaded in less than fifteen minutes.



Fuel Distribution Depot

Mounted on concrete cradles within enclosures, consisting of reinforced concrete walls 9in thick and 5ft 6in high, are two tanks, each of 12,000 gallons capacity, measuring 30ft long by 9ft diameter, and a slop tank 10ft 6in long by 5ft diameter, having a capacity of 2000 gallons. Not far from the tank enclosures is the concrete pump slab, upon which are two Sigmund pumps, each rated to deliver 250 gallons per minute and driven by a flameproof and weatherproof 10 h.p. Crompton Parkinson electric motor. The third sonpen of the site is the loading island, upon which are installed two loading arms; overhead is a canopy carried on tubular supports which incorporate an elevated handrail to assist loaders when on top of a tanker. The site, including the plant and the operational area, measures 140ft by 115ft, and there is space for more tanks to be mounted. Provision has been made for installing a third pump on the pump slab and for erecting four more loading arms on the loading island. At present Mobilgas "pool" petrol is stored, but Mobilgas special will be available on February 1, 1953. It is planned to install a tank for diesel fuel, together with the necessary ancillary equipment, at an early date.

Steel pipes having welded flanges and cast steel valves form the piping system. When filling operations are in progress the petrol leaves the main storage tank through a 6in main tank valve to a short length of pipe, then by way of a 4in. isolating valve and a 4in main suction valve to an individual centrifugal pump. This passes the fuel through a 4in isolating valve to an air eliminator, from which vent pipes are led back to the main storage tank. A 4in non-return valve on the discharge side of the air eliminator prevents any flow back from the loading arm, and the petrol is discharged through 4in diameter piping to the loading island manifold. Here each loading system includes a 3in isolating valve, a 3in strainer, an angle neck flow meter, which measures up to 250 gallons per minute, a 3in control valve and a 3in isolation valve. The angle neck flow meter is so placed that it is visible by a loader when on top of the tank wagon, and the flow control valve has been fitted adjacent to the flow meter, because at a later date the pump capacity will be increased beyond the meter rating, while the function of the isolation valve is to isolate the flow meter for maintenance purposes. A 3in diameter pipe leads to the loading arm standpipe, and so to the loading arm, which is fitted with a spring-loaded slow-closing deadman handle operated loading valve. The loading arm, which has a span of 24ft, is of recent design, being of spring balance pattern with double buffer springs and bar, so eliminating the old style balancing arm.

As arranged, the system is one-man operated; that is, the tank loader has only to press a starter button to start up the pump, and then operate the "deadman" loading valve. With the aid of floodlighting, loading of tank wagons can be carried out by day and night.

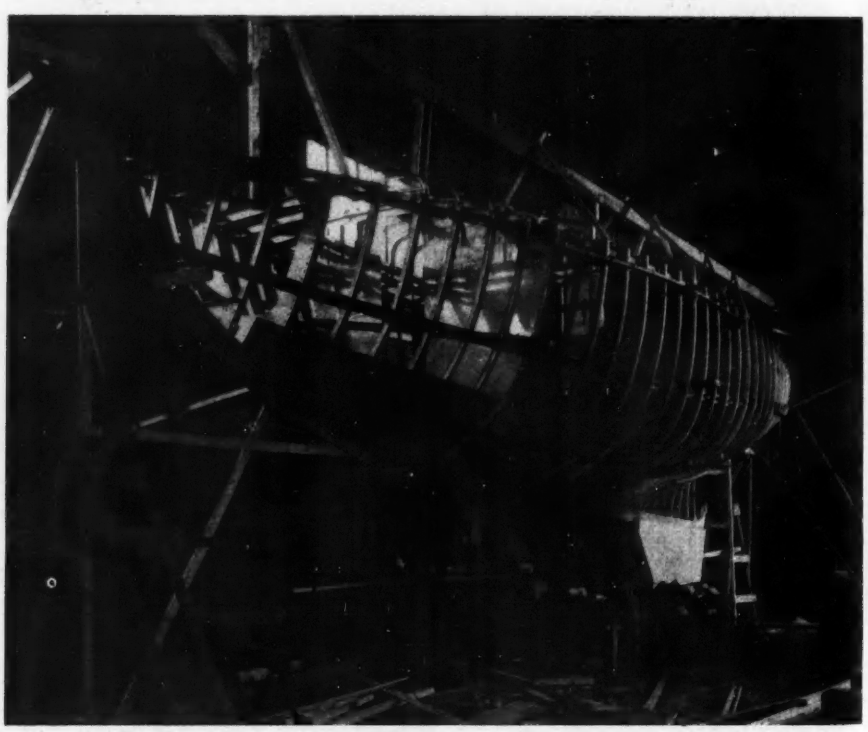
For filling the main tanks the isolation valve to the air eliminator is shut, so isolating the discharge line to the loading island, and also the isolation valve in the main discharge line to the pump. A flexible suction hose is connected to the pump and the fuel is pumped through a by-pass line into the main pipeline to the storage tank.

Special arrangements have been made to deal with any leakage which may occur; leakage from the main tanks and any spillage at the loading island is led by drains to an interceptor installed below ground level. This interceptor, is designed to separate fuel from storm water, so that there is no possibility of any fuel entering the main drains. Since there is fuel in the discharge line to the loading island, the question of expansion of the contents of the line in hot weather was considered, and to avoid any undue pressure being set up a spring-loaded by-pass valve was fitted to the line and connected by a ½in diameter pipe to the main tank. Dry chemical fire extinguishers are available to deal with any danger from this source.

The consultants for this installation were Messrs. Maunsell, Posford and Pavry, and it is understood that the Vacuum Oil Company has under construction several other fuel distribution depots, notably at Coventry, Sunderland and Wandsworth.

Auxiliary Cutter "Coimbra"

ALTHOUGH aluminium alloys are comparatively new as boat-building material compared with the traditional material, wood, nevertheless they are being increasingly considered by designers and prospective owners for the construction of small craft. This tendency has, no doubt, been influenced by the success which has attended the application of the metal to this purpose, especially since the war. The initial cost remains considerably higher than mahogany, but is on a par with teak; however, by careful ordering waste is cut to a minimum, so that the material cost differential is reduced to a reasonable amount. Ease of fabrication of the metal is reflected in lower labour costs and, besides the question of inital cost, the light metal construction offers a considerable reduction in



Yacht "Coimbra" Under Construction

weight and also low maintenance costs. The latest example of aluminium alloy as applied to yacht construction is the "Coimbra," which has been designed by Laurent Giles and Partners, Ltd., for Mr. N. B. Redfern, of South Africa, and built by Hugh McLean and Sons, Ltd. This 40ft ocean-going auxiliary cutter has a length on the water line of 32ft, a beam of 10ft 6in and a draught of 6ft 3in, the Thames measurement being 15 tons and the displacement 11·6 tons. Auxiliary power is provided by 10/24 h.p. Parsons Ford petrol engine to give the vessel a speed of between 5 and 6 knots.

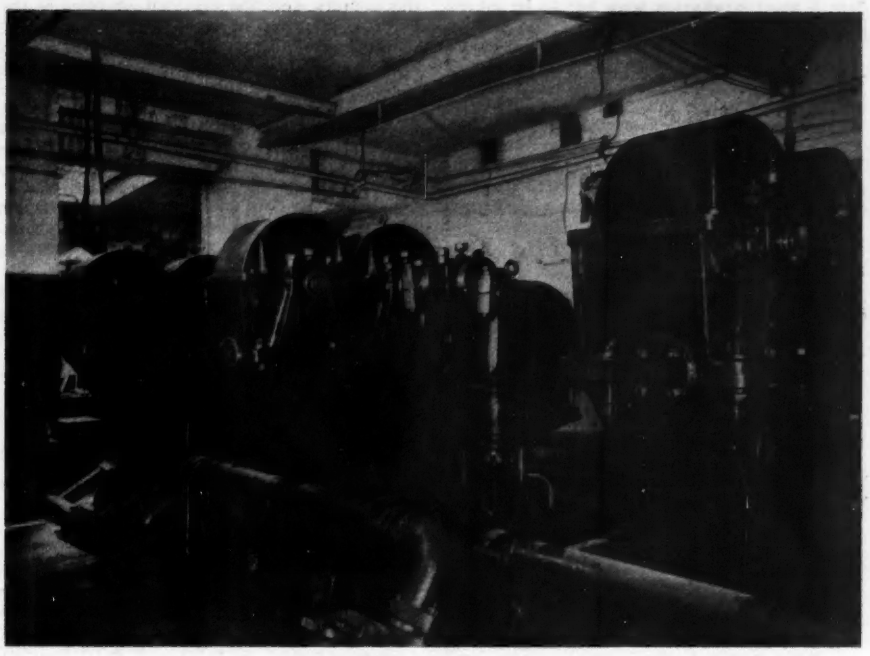
The yacht has been designed with a 'midship cockpit; under this is the engine-room, which extends for the full width of the boat and, besides housing the engine, provides space for two 50-gallon fresh water tanks, two 20-gallon petrol tanks, stores and batteries. The owner's cabin is aft of the engine-room and it is entered from the main cockpit, while right aft is the working cockpit with sail bins to port and starboard.

The cutter, which is constructed of aluminium alloys supplied by the British Aluminium Company, Ltd., has been built with reverse sheer. The shell plating, to Standard Specification NP 5/6, is $\frac{1}{4}$in thick; it is flush riveted to frames spaced 1ft 1in apart, and the butts have inside straps. Aluminium alloy to Specification NS 4 and $\frac{1}{4}$in thick forms the stem piece, and the No. 10 gauge deck plating is supported on beams consisting of 2in by 1½in by $\frac{1}{4}$in and 1½in by 1½in by $\frac{1}{4}$in ordinary angles and sheathed with teak 1½in thick. The floors are of $\frac{1}{4}$in thick plate and the bulkheads are of No. 6 gauge material, while No. 10 gauge sheet has been used for the superstructure. A cast iron ballast is fitted and bolted to the hull. Aluminium alloy extrusions have not been used for the mast and boom, which are both made of spruce.

The owner and a crew of six are sailing the yacht to South Africa by way of South America, so that on arrival at her home port, Port Elizabeth, the cutter will have proved herself.

Replacement of Hydraulic Lifts by London Transport

THE last of its hydraulic lifts was recently taken out of service by London Transport. The three lifts in question were at the Highbury station on the Northern City Line, and they have been in use for forty-seven years since 1904.



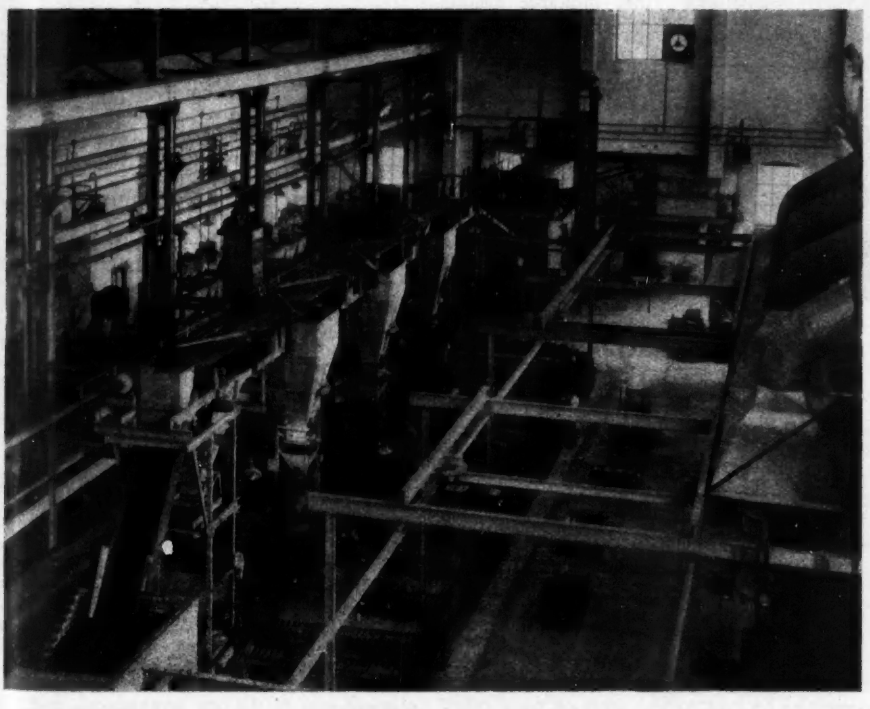
Old Hydraulic Lift Pump Room

In the interests of economy and as the probable future traffic at the station could not be predicted with any accuracy, it was decided to replace the hydraulic lifts with two Otis electric lifts, which became redundant at Baker Street station just before the war. The two electric lifts were installed in 1906, but as they have not been used since 1940, their effective age is only thirty-four years. They have been thoroughly overhauled and are considered capable of giving reliaole service for many more years.

The three hydraulic lifts at Highbury were arranged in line in a common oval shaft constructed by joining three 23ft diameter shafts. Two accumulators were provided, one as a balancer for the lifts and the other as a reservoir for the supply of water; they were installed in the centre of the spiral staircase in the emergency stairshaft. Hydraulic pressure was provided by three electrically-driven pumps, housed with their control gear in the machine room at basement level, shown in the photograph reproduced above.

The electric lifts are similar to those used for many years at other London Transport stations; the lift machines are of the drum type, the rope drum being driven and supported by tandem worm gears at both ends. Each worm gear is driven by an electric motor, and the motors are connected in series to the 600V d.c. traction supply.

Each lift car is suspended by four main lifting ropes, which are wound on to the drum at the same time as two counterweight ropes are wound off. There is a second counterweight which is connected directly to the lift car by two independent ropes. So far as the cars are concerned, however, those used at Baker Street were too large for the Highbury shafts, therefore new cars have been constructed and the existing safety gear modified to suit.



A Non-Ferrous Foundry

A Non-Ferrous Foundry

As part of a scheme for the extension of capacity for the manufacture of industrial instruments at the Biscot Road Works of George Kent, Ltd., of Luton, the non-ferrous foundry of the company has been moved to the recently acquired Lea Works, where a new foundry has been laid down. This new foundry went into production on August 5th last, and in its first week it turned out some 11 tons of pressure-tight castings for the firm's water, oil, steam, air, gas and petrol meters.

The foundry, which occupies 20,000 square feet, is now producing 15 tons of sand castings per week, in weights from a few ounces to 3000 lb, in fifteen or more different alloys. It forms the first part of a plan to devote the Lea Works to the manufacture of Kent small mechanical meters for water, oil and petrol. As can be seen from the photograph we reproduce herewith, the new foundry is highly mechanised and incorporates modern sand handling and reclamation plant.

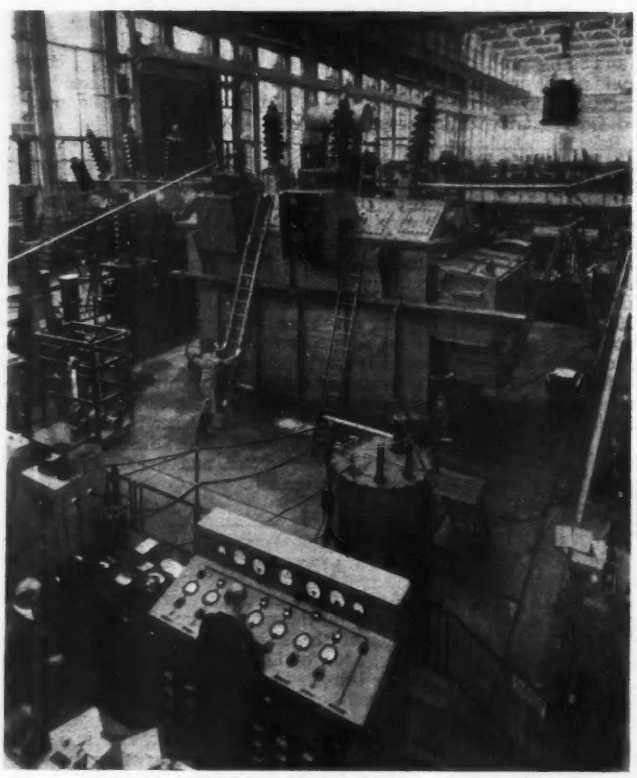
When the new establishment was being planned, a very tight schedule was fixed for each stage of the construction and move, and strenuous efforts were necessary to maintain this schedule. For instance, a knock-out pit of 130 cubic yards was dug with a mechanical excavator in two days. As much machinery as possible was moved from the old foundry before the works holidays began on July 18th, only the bare essentials to main

tain a good production were left to be moved to the new foundry during the second week of the holidays. At the new foundry, the mould stove could not be finished, nor could the tower core oven be moved until the holiday period, as they were in use until the last day. These units were transferred during the holiday period, together with two core blowers, three moulding machines, four furnaces, two shot-blast appliances, a 2-ton crane and gantry, 100ft of roller track, core shop equipment, fettling apparatus, moulding boxes, sand, &c.

A 100 MVA Transformer

A TRANSFORMER which has been built at the works of Ferranti, Ltd., Hollinwood, Lancs, for the Low Road substation of the Yorkshire Electricity Board, Leeds, will, it is stated, be the largest unit of its kind in service in this country. This transformer, which is one of two similar units, can be seen undergoing tests in its makers' works in the photograph reproduced below.

It is a 100MVA, three-phase, 132/33-kV star/delta connected transformer, and is provided with on-load tap changing gear on the 132kV winding of the continuously rated reactor design. It has a self-cooled rating of 50 per cent and is provided with two banks of air-blast cooled radiators with forced oil circulation.



100 MVA Transformer

In the voltage tests applied to the transformer, the impulse test voltages were : high, 550kV ; low, 200kV ; and in the over-potential tests the high voltage was 372kV and the low voltage 93kV.

When the transformer was dispatched from the works, the weight of the load, including the trailer, was 172 tons, and added to this there were three tractors, each weighing 9 tons.

Forest Products Research Report

THE annual report of the Forest Products Research Laboratory was published this week. It states that the advisory work and the investigation of the properties and uses of the new tropical timbers which are being imported into this country were the principal activities at the laboratory during the year, and comments that the amount of this day-to-day routine work has limited the time and attention which should rightly be given to long term fundamental research. The report suggests that the present lack of balance between routine work and basic research should be corrected as soon as circumstances permit.

Tropical Timbers and Their Uses.—Work which has been done in discovering the characteristics of the many tropical hardwoods which are being imported is outlined. The work done has included testing for strength, durability and resistance to abrasion. In addition, the behaviour of the timbers during seasoning, machining, steam bending, nailing and impregnation of preservatives has been studied.

From studies of the physiology of hardwood formation, it is clear, the report maintains, that the girdling technique for sap flow interruption does not appreciably affect the vitality of the tree or cause serious fungal infection of the sawn girdle. Though the results are of some interest, no widespread increase in the proportion of fully-developed hard wood has yet occurred. In another section, the report dwells upon kilns and kiln seasoning. Mention is made of an experimental chamber for the seasoning of certain timbers in superheated steam at atmospheric pressure and of exploratory drying tests using boiling oil. The results of both processes are described and abnormal shrinkage due to serious degrade is reported.

The report records in some detail the mechanism of wood cutting and compares the shearing and compression processes involved with those of metal working. Reference is made also to theoretical studies in sawing and to the derivation of the best saw-cutting actions.

A considerable portion of the report is devoted to entomology and mycology.

It notes that the House Longhorn Beetle, a pest which is considered so serious in some Continental countries that insurance against its ravages is compulsory, has been reported in various places in England during recent years. The report describes a survey in Surrey during which eight out of eleven houses in one road were found to have the beetle in their roof timbers. Fifteen out of twenty-nine houses in another road were found to be infested, the beetles attacking not only roofs but fencing, ornamental woodwork and garden sheds. Longhorn beetles are being bred in the laboratory in order that their biology and rate of development can be studied.

The prevalence of decay in the timbers of small craft, the report continues, is a widespread problem. It has been estimated that £1,500,000 is spent yearly on the repair of yachts alone, with a further £1,000,000 on the repair of open boats, fishing and commercial craft. The laboratory is co-operating with naval architects and yacht designers in making available information on the subject. The problem is of considerable importance also in many tropical countries and extensive repairs are often needed to modern craft operating in fresh water overseas. Samples of fungi and of decayed timbers from vessels operating on East African lakes are being examined at the laboratory in an attempt to find the best methods of preserving this kind of craft.

French Engineering News

(By Our French Correspondent)

A new coking plant at Siladiere has come into operation. Started in 1949, it comprises sixty Disticoke-Becker ovens arranged in groups of four. Each one has a capacity of 20 tons of coke per twenty-four hours, or a total of 1200 tons daily. By-products are expected to reach about 28kg to 30kg per ton for coal tar, 10kg to 11kg of ammonia and from 9 to 10 litres of benzol per ton. The new plant is replacing three others which were situated at Meons and which were destroyed in 1944. All the gas produced by the new plant will be dispatched to the Gaz de France plant at Etivalliere.

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It is announced by the firm of Sollac that an important plant for the production of thin sheet and strip steel will come into production shortly. In the 700m long shops, strip from 20cm to 25cm thick are rolled at speeds of up to 1550m per minute.

* * *

The Ministry of Public Works has included the electrification of the Lyons-Marseille line in the five-year electrification programme. It is estimated that the completion of this scheme would involve a saving of about 350,000 tons of coal yearly. The increase in power consumption would be about 260,000,000kWh. The power requirements will be supplied by the recently inaugurated Donzere-Mondragon plant.

The electrification of this section of line was supposed to have followed that of the Paris-Lyon line, but credit was withheld and the completion of the work was not possible. The French Railways are stated to be now considering a new plan which would cut out electrification and increase the use of diesel traction. Several smaller branch lines will be electrified this year and next, but the electrification of the main line is likely to be held up for the time being.

The decision of the Ministry of Public Works may force electrification, but meanwhile the railways are going ahead with plans for speeding up traffic on the line by the installation of automatic signalling systems, and a complete rebuilding programme is to be drawn up for stations and marshalling yards in order to leave the way as clear as possible for the Paris-Marseille trains. Passenger platforms are to be lengthened to 400m and important modifications are to be carried out at Vienne, Saint-Ramnert-d'Albon and Valence.

* * *

The French Prime Minister has opened the new French Steel Research Institute at St. Germain en Laye. This laboratory is designed on similar lines to laboratories in Germany, Switzerland, Great Britain, and Sweden. It will undertake research on coking plant, heat and furnaces, and in collaboration with the large steel firms several important metallurgical investigations will be undertaken.

* * *

The Gaz de France has announced that, despite the vast increase in the use of petrol and heavy oil, the industrial use of gas is also developing. Based on an index figure of 100 in 1946, consumption rose to 116 in 1950 and 122 in 1951. The index delivery of coke over the same period jumped from 147 to 164.

It is estimated that in 1950 industry used 673 million cubic metres of gas and that in 1951 that figure rose to 765 million cubic metres.

* * *

The Paris Metro has released more information about the pneumatic-tyred coaches now undergoing tests on a part of the Paris Metro network now out of use.

The train is tested daily and has already covered 20,000km. The pneumatic tyres are said to show practically no signs of wear, and it is estimated that they will easily cover 300,000km before needing change.

It is expected that three lines, Lilas-Lavallois, Vanves-Invalides and Pré-St.-Gervais will be changed over to the new arrangement, and the Metro Administration is stated to have asked for authorisation to carry out the conversion.

Industrial and Labour Notes

Britain's Overseas Trade

The provisional figures for overseas trade in October, which were issued by the Board of Trade at the end of last week, put the value of exports of United Kingdom goods during that month at £218,500,000. The monthly average value of exports in the third quarter of this year—based on twenty-six working days per month—was £191,300,000.

There were twenty-seven working days in October, but even so, the Board of Trade says, the figure recorded represents an increase of nearly 10 per cent in the daily rate of export. At the same time it is pointed out that it is customary for exports to rise in October after the lower values recorded in the holiday months. Imports into the United Kingdom in October have been valued provisionally at £266,900,000, compared with a monthly average of £262,600,000 in the third quarter. The total value of imports for the first ten months of this year was 9 per cent below the average for 1951. With re-exports in October at £12,100,000, the excess of imports (c.i.f.) over total exports (f.o.b.) was £36,300,000, compared with £61,100,000 a month in the third quarter.

In presenting these figures, the Board of Trade has given some particulars of British exports to North America during October. Their value is stated to have been £28,600,000, compared with a monthly average of £23,200,000 in the third quarter and £21,000,000 over the first half of this year. In the first ten months of this year United Kingdom exports to North America have averaged £22,400,000 a month, compared with £23,600,000 in the same period of last year.

Volume of Trade in the Third Quarter

According to a survey published in *The Board of Trade Journal*, the indices of the volume of United Kingdom trade on a new base year (1950) show that, in the third quarter of this year there was a general contraction in both imports and exports compared with the first and second quarters. Using the new index numbers, the volume of United Kingdom exports in the third quarter is estimated as being about 7½ per cent below the second quarter level, a level which was itself depressed by the fact that this year the second quarter included both the Easter and Whitsun holidays. On the same basis, the volume of exports for the first nine months of this year has been computed as 6 per cent below the average for 1951.

The Board of Trade says that there was a substantial decline in the volume of exports of engineering products in the third quarter to a level 17 per cent lower than in the first half of this year. Machinery exports, which in the first half of the year averaged 10 per cent more than in 1951, fell back during the third quarter to less than in 1951, and the same applied to electrical goods. In the case of vehicles, the volume of exports in the first six months was slightly above the 1951 average, but in the third quarter there was a drop of nearly 20 per cent. The Board of Trade's comment on the situation is that the falling-off in the volume of engineering exports in the third quarter may be due to the effect of holidays on output, but just to what extent it will be difficult to determine until the figures for the fourth quarter become available.

The index number of the volume of total imports in the third quarter was 94·3 (1950=100), compared with 106·3 in the second quarter and 112·7 for 1951 as a whole. Compared with the large volume of imports in the third quarter of 1951, there was a fall of 20 per cent in the third quarter of this year, and the volume of imports for the first nine months of this year was 7 per cent lower than in the corresponding period of 1951.

The Index of Industrial Production

The Central Statistical Office of the Treasury has prepared a note giving some explanatory details about the index of industrial production which it compiles every month. This monthly index of production is intended, of course, to be a guide to the level of industrial activity in the country. It measures output for all purposes—home consumption, defence, investment and export.

The note now published deals with the new index which the Treasury has used since July last and which has replaced its "interim index" used since 1948. As the full results of the first post-war census of production—initiated in 1948—have now become available, it has been possible to replace the interim index by the new index, which combines, in a single series, movements in all the different branches of industry. The scope of the index is confined to industrial production by private or public concerns in the United Kingdom and covers mining, all kinds of manufacturing, building and public utilities. It does not, however, include agriculture, forestry, fishing, transport, distribution and other sections of commerce or public and private services. The new index incorporates 1300 production "series," or figures for individual lines of production, most of them representing the physical quantities produced. This kind of series is used wherever possible, although for some industries it is not available and other measures of output are used. For building, parts of the engineering industry, clothing and a few other trades the measure is value of production adjusted for changes in price. For some other industries, series of quantities of the main materials used in production, or the number of people employed, are used. For building and shipbuilding, where production of one item extends over a long period, allowance is made for work in progress.

After the "series" have been selected, the next problem is to combine them into a general "index number." This is done by means of "weights" which reflect the relative importance of different industries in 1948, according to their net output as shown by the Census of Production for 1948. The level of production in each month is accordingly expressed as a percentage of average monthly production in 1948, which is taken as the base year. It should be borne in mind that the index is designed to compare levels of production in different months. Calendar months, however, do not all contain the same number of days, and adjustments are made for variations in the number of days in each month, excluding for each industry those which are not normally working days. In effect the index compares average weekly rates of production in different months. No adjustment is made for holidays or for seasonal influences, the effects of which are therefore reflected in the index.

The explanatory note about the index is published by H.M. Stationery Office, price 2s. 6d.

Conditions for Productivity

This week the annual report of Tube Investments, Ltd., has been issued. It includes a statement by the chairman, Mr. Ivan A. R. Stedeford, which not only reviews the activities of the company, but makes also several observations on economic and industrial affairs generally.

In one part of his statement, for example, Mr. Stedeford comments on what he calls "conditions for productivity." He says that, despite a substantial and progressive increase in this country's output and productivity since the war, it is apparent that the overall result is yet far from adequate, and that most American industries are still operating at substantially higher levels of productivity then are their British counterparts. There is no mystery, Mr. Stedeford adds, about the way these American developments are being achieved. They stem in the main from a phenomenal capital investment in new plant; the rapidly increasing use of electronic control techniques; and the further application of highly geared automatic production lines by the spread of such devices as the transfer system of machines, which uses the principle of the automatic assembly line for machining and other initial working operations.

Mr. Stedeford goes on to say that Britain's answer to this formidable challenge has had to be a curtailment of development expenditure, a drastic tightening of credit, and additional taxes on an industry already overburdened with them. Our present position, he suggests, leaves little room for economic manœuvre, and short-term crises may sometimes require treatment inimical to our long-term interests. Nevertheless, Mr. Stedeford remarks, it seems abundantly clear that the handicaps now imposed upon British industry are too burdensome and that, short-term in intention, too many become long-term in effect. Official hopes have been expressed, the statement continues, that greater expenditure on the expansion and modernisation of industry—though far short of what is needed—will be possible next year. But Mr. Stedeford emphasises that the matter is of greater urgency. He questions whether we can afford—in any circumstances, and particularly in times of a production crisis—to continue to "go slow" technically as we are now doing, while others advance at the double. If, Mr. Stedeford says, the productivity prospects of our world competitors fulfil their promise, industrial enterprise here will be challenged with still graver problems unless we are permitted the means, on comparable terms, of reaching substantial technical equality. What is needed, Mr. Stedeford considers, is a new national standard of values in which technical progress and productivity enjoy a much higher status than they are granted to-day.

Productivity in Foundries

There has recently been held in Paris a conference on "Foundry Productivity," which was arranged by the Organisation for European Economic Co-operation and attended by delegates from the United Kingdom, Belgium, Denmark, France, Germany, Eire, Italy, Luxembourg, the Netherlands, Sweden and Switzerland. The delegates included representatives of trade associations, officials of firms which have conducted productivity experiments, and experts who have studied foundry productivity in the U.S.A.

During the conference, conditions under which productivity experiments were carried out in various countries were described. The discussions revealed that the primary obstacle to increased productivity was the conservative attitude of both employers and employees to any change in working methods, the specialists present emphasising that initiative was required not only from individual firms, but from the trade as a whole. Further, it was agreed that, when a new attitude had been created by improved human relations. it was much easier to carry out certain basic reforms in labour organisation. Several delegates explained how their firms had managed to reduce working hours, increase production and make foundry work more effective and agreeable. Others described how handling costs—a large item in total production costs—could be reduced at relatively small expense.

Finally, much consideration was given at the conference to the importance of technical consultation services on foundry subjects and their part in increasing productivity. A suggestion was cordially approved that a European liaison committee should be set up to organise an exchange of information on what is being done to increase productivity in foundries. Another suggestion made—by the United Kingdom representatives—was that a further conference, to be held in this country, should be arranged by the O.E.E.C.

Notes and Memoranda

Rail and Road

THE LATE MR. A. H. GLASSPOLE.—We have learned with regret of the death of Mr. A. H. Glasspole, sales engineer of Commer Cars, Ltd., which occurred on Saturday last, November 15th. He had been associated with the British motor car industry for over forty years, and had served on several technical committees concerned with commercial vehicle design and development. Mr. Glasspole joined Commer Cars, Ltd., twenty-six years ago.

B.R.F. BOOKLET.—The British Road Federation's latest publication, "Road Pence—Road Sense," shows graphically that, where the cost of road works can be counterbalanced by reduction in vehicle operating costs and road accidents, the construction of new roads, improvements and a better standard of maintenance are as justifiable as any other form of capital investment. The booklet is a popular version of a paper entitled "The Economic Justification of Road Works," read by Mr. Christopher T. Brunner, vice-chairman of the Federation, and this year's president of the Institute of Transport, at the Ninth Congress of the Permanent International Association of Road Congresses held in Lisbon last year.

STAFF TALKS ON JOINT CONSULTATION.—Railwaymen of all grades who have been elected by their colleagues to represent them at Local Departmental Committees or Sectional Councils are to meet management representatives in a series of five-day conferences arranged by British Railways. These conferences, of which there will be sixteen, are designed to give those railwaymen who are particularly concerned with all aspects of staff relations a greater insight into the practicability and the value of joint consultation. The conferences are to be held at the Manor House, Shanklin, Isle of Wight, and the first started on November 10th. According to the programme, each conference will first review the aims of joint consultation and then divide into nine syndicates to discuss a given subject. The conference will then reassemble and the subject will be discussed in open meeting. This procedure will be repeated for each subject discussed and the session will end with a review of the conference and remarks by the chief instructor.

RE-RAILING DEVICE FOR BRITISH RAILWAYS.—A German re-railing equipment which has been ordered by British Railways is designed broadly on the principle of the hydraulic motor-car jack. With this equipment, heavy hydraulic jacks raise a derailed locomotive, carriage or wagon to rail level, and a crank and chain apparatus is then used to haul the vehicle sideways into position, after which the jacks are released to lower it on to the rails. If the vehicle is overturned as well as derailed, it is first brought into the upright position by means of link chains and hydraulic jacks. The largest of the jacks is stated to be capable of lifting a weight of 150 tons through a height of 18in. Power for the jacks is provided by a self-contained diesel-operated air compressor, and the air pressure is converted to a pressure of more than 4000 lb per square inch in the hydraulic jacks. It is said that the advantages of the equipment over the usual steam crane are that operations are speedier and the work can be carried out without interruption to traffic on adjacent lines. We are informed that if experience with the new equipment warrants it, further sets may be built in British Railways workshops.

Air and Water

OIL POLLUTION.—The yacht "Gay Caprice," which was chartered by the oil companies for the purpose of following the course of oil patches discharged up to 100 miles out to sea, had completed four voyages, and valuable data have been collected concerning the rate of drift, and the tendency to coagulate, disintegrate or sink.

AIR TRAFFIC FOR SEPTEMBER.—Air transport movements recorded at United Kingdom aerodromes in September, 1952, totalled 21,878, 4·3 per cent more than in September, 1951. Passengers handled totalled 363,350, a 6 per cent increase on the number for September, 1951. Freight on and off-loaded at 4717·4 short tons showed a decrease of 9·8 per cent, and Post Office mail set down and picked up decreased from 1072·5 to 1059·1 short tons. At London Airport there were 3532 air transport movements, and passengers handled totalled 102,596, an increase of 6·8 per cent. Northolt recorded 5015 transport movements, and passengers handled decreased by 5·1 per cent to 97,268. Airports at which passenger traffic increased considerably over September, 1951, were :—Manchester (Ringway), 21,328 (36·7 per cent increase); Prestwick, 19,297 (16·2 per cent increase); Belfast (Nutts Corner), 19,051 (13·4 per cent increase); Glasgow (Renfrew), 18,336 (12·1 per cent increase); and Isle of Man (Ronaldsway), 15,738 (10·5 per cent increase). Edinburgh (Turnhouse) passengers increased by 26 per cent to 4087. Jersey Airport handled 39,671 passengers, an increase of 18·2 per cent, and Guernsey 16,892, an increase of 27·2 per cent.

INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships, tenable for three or four years, according to the length of the course at the University selected, will be offered for competition in 1953 :—Naval Architecture : Institution of Naval Architects, £175 per annum; age limit under 23; open to British apprentices or pupils in the Royal Dockyards or private shipyards; entries close January 15, 1953. Trewent, £175 per anum; age limit under 19; open to British subjects who are, or have been, apprentices or pupils in private shipyards; entries close May 30, 1953; Denny, £175 per annum; age limit under 19; tenable for four years at Glasgow University, with apprenticeship of five years; open to British subjects who have not yet begun their apprenticeship, or served not more than one year of it with Messrs. William Denny and Bros., Dumbarton, and who have previously attended an approved Public School or a school under an education authority; entries close May 30, 1953. Marine Engineering : Parsons, £175 per annum; age limit under 21; open to British apprentices or pupils in marine engine works or the Royal Dockyards; entries close May 30, 1953. Denny, £175 per annum; age limit under 19; same conditions as for Denny Scholarship in naval architecture. Full particulars of the above Scholarships may be obtained from the Secretary of the Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1.

APPRENTICE EXAMINATION AWARDS.—Thirty members of the apprentice training scheme in the Hayes group of factories of the Fairey Aviation Company, Ltd., have been presented with cash prizes by the company for recent examination successes. Candidates who obtained the Higher National Certificate received a cheque for £10, whilst successful candidates for the Ordinary National Certificate and other examinations received £5 each.

Miscellanea

SUNDERLAND DEVELOPMENT PLAN.—The Minister of Housing and Local Government has approved, with modifications, the development plan for the County Borough of Sunderland.

YORK POWER STATION.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the installation in York power station of a 20MW turbo-alternator set and two boilers, each having an evaporative capacity of 100,000 lb of steam per hour, in replacement of the plant which was destroyed when a boiler exploded in the station in October, 1949.

PETROLEUM EQUIPMENT.—We have received a copy of *British Petroleum Equipment News* for autumn, 1952. This volume gives particulars of a diesel pusher tug for West Africa and some notes upon developments in Saskatchewan, and also includes short articles describing a patented liquid expansion system, filling road and rail tankers, a modern electric hammer drill, and four items of equipment.

IRON AND STEEL INSTITUTE.—The autumn meeting of the Iron and Steel Institute will be held at 4, Grosvenor Gardens, London, S.W.1, on Wednesday and Thursday next, November 26th and 27th. On the first day there will be two sessions, beginning at 10 a.m. and 2.30 p.m. The proceedings on the second day will occupy the morning only, from 10 a.m. to 1.15 p.m. On Thursday, December 11th, at 4, Grosvenor Gardens, S.W.1, the twentieth meeting of the Iron and Steel Engineers' Group is to be held, beginning at 9.30 a.m. and ending at 4 p.m., with an interval from 12.30 p.m. to 1.45 p.m., during which a buffet luncheon will be available.

THE LATE MR. J. S. DANIELS.—We record, with regret, the death of Mr. John Stuart Daniels, which occurred at his home at Whitecroft, Nailsworth, Glos, on November 13th. Mr. Daniels, who was in his seventy-ninth year, was chairman of T. H. and J. Daniels, Ltd., of Stroud, with which firm he had been actively engaged for more than sixty-three years. The firm was founded by his grandfather, Thomas Daniels, in 1840. Mr. Daniels was a member of the Institution of Mechanical Engineers, and a past-chairman of its western branch. He was also a member of the Institution of Production Engineers, the Institute of British Foundrymen and the Plastics Institute.

MACHINE TOOL DRIVES.—A new publication of the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, deals in detail with machine tool drives. After giving useful notes on the choice of motors, the publication deals with a.c. polyphase induction motors, stator and rotor units, high and ultra-high speed motors, polyphase variable-speed and multi-speed d.c. motors and generators, fractional horsepower motors, electro-hydraulic thrustors, electromagnetic "Perigrip" brakes, control equipment, and profiling systems. The information is given in a clear concise way, supplemented with many useful illustrations and drawings of typical units and machine tools.

AWARD OF ROYAL MEDALS.—Her Majesty The Queen has been graciously pleased to approve recommendations made by the council of the Royal Society for the award of the two Royal Medals for the current year, as follows : to Sir Frederic Bartlett, C.B.E., F.R.S. (Cambridge), for his creation of an experimental school of psychology which has established under his leadership an outstanding position recognised internationally as without superior ; and to Professor C. K. Ingold, F.R.S. (London), for his extensive theoretical and practical studies of the mechanism of, and the factors influencing, organic chemical reactions, and for his analysis of the structure of benzene.

CARE OF BEARINGS.—A useful publication, entitled *Taking Care of Bearings*, has been issued for the use and guidance of engineers, fitters, and others concerned with the installation and maintenance of ball and roller bearings, by the Fischer Bearings Company, Ltd., of Upper Villiers Street, Wolverhampton. Using brief notes and a large number of graphic illustrations, the booklet emphasises the need for cleanliness, the importance of careful inspection of seatings and housings for bearings, right and wrong means of assembly and dismantling, lubrication and protection, and fitting allowances. It concludes with tables giving recommended limits for housings and shafts for bearings and some useful conversion tables.

JET ENGINE LUBRICANT.—A new grease, containing neither soap nor mineral oil, has been developed at the Shell aero engine laboratory at Thornton, Cheshire. This lubricant, "Aero Shell Grease 12," which is made with an inorganic gelling agent and synthetic oil, has been approved by the Ministry of Supply and is claimed to have satisfactory lubricating properties over a temperature range of between −70 deg. Cent. and +200 deg. Cent.

TITANIUM PILOT PLANTS.—Imperial Chemical Industries, Ltd., has been carrying out a three-year research and development programme covering the manufacture of titanium. The board of the company has now decided that this work has reached a stage where an immediate start can be made on the erection of pilot plants for the production of wrought titanium and its alloys. When these plants are in production they will provide a British source of supply for the development of prototype applications in the engineering and aero engineering fields.

CUTTING OILS.—We have received from the Regent Oil Company, Ltd., a copy of its new cutting-oils journal, which has just been published under the title *Lubricants and Coolants for Cutting and Grinding*. There are some general remarks upon cutting fluids, followed by a section in which the various functions of cutting fluids, such as heat dissipation, lubrication and prevention of corrosion, are discussed. The general types of cutting fluids are briefly touched upon, followed by some notes upon the handling of cutting oils and also advice concerning dermatitis, its prevention and cure. Information regarding various "Caltex" cutting fluids and drawing compounds is contained in the next section of the publication, together with charts giving cutting speeds and the correct cutting fluid to be used with both ferrous and non-ferrous metal for various machining operations.

WINTER TRANSPORT.—A meeting to review the inland transport position for the coming winter recently took place between the British Transport Commission, the Railway and Road Haulage Executives and the Association of British Chambers of Commerce, Federation of British Industries, National Farmers' Union, and National Union of Manufacturers. The meeting recognised that freight traffic is at present moving freely by rail and road and that more tonnage could be handled by both Executives. It was agreed that unless winter conditions were abnormally severe there was every prospect that inland transport would be adequate to all requirements during the coming winter. Nevertheless, as abnormally bad weather, fog and illness are always possible, the conference agreed to keep in being the liaison machinery set up throughout the country last winter, to be brought into action, if necessary.

A JOINT RING CUTTING MACHINE.—A simple portable ring-cutting machine, which is designed on the same principle as the large machines for cutting rings out of sheet, installed in its works, is now being made by Richard Klinger, Ltd., Sidcup, Kent, for users of its jointing materials. This machine, which can also be used for cutting other materials such as cardboard, rubber, cork, felt, &c., is speedier to operate and simpler to use than hand tools. With the new machine, it is possible to cut rings up to an outside diameter of 48in, down to a minimum inside diameter of 2in. A steel tape attached to the machine is marked in both centimetres and inches for setting to size, and it is stated that it takes less than 20 seconds to cut a "Klingerit" joint ring, 24in in diameter and $\frac{1}{16}$in thickness. The machine is supplied complete with one spare cutting wheel one $\frac{1}{8}$in punch for making the centre hole in the sheet of jointing and one $\frac{1}{8}$in thick base disc, 15in in diameter.

Personal and Business

LODGE PLUGS, Ltd., states that Mr. V. Martin-Jones, technical sales manager, has been appointed a director.

HOOVER, Ltd., states that its Nottingham district showroom and offices are to be moved shortly to 60, Derby Road, Nottingham.

THE AIR MINISTRY announces the appointment of Air Commodore A. F. Hutton, C.B.E., as senior air staff officer, Technical Training Command, with the acting rank of Air Vice-Marshal.

MR. C. R. PRICHARD, Mr. R. A. Banks, Dr. James Taylor and Dr. Ronald Holroyd have been appointed directors of Imperial Chemical Industries, Ltd.

ROLLS-ROYCE, Ltd., announces that Air Commodore E. R. Pearce, O.B.E., B.Sc., has been appointed North American sales representative for the Aero Division and will be stationed with Rolls-Royce of Canada, Ltd.

BRITISH ELECTRONIC PRODUCTS (1948), Ltd., which is part of the Lancashire Dynamo group of companies, has changed its title to Lancashire Dynamo Electronic Products, Ltd. The firm's headquarters continue to be B.E.P. Works, Rugeley, Staffordshire.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the appointment of Mr. S. J. Clarke as manager of the Newcastle upon Tyne district office in succession to Mr. F. C. Barford, who is taking up another position in the company's service. At present, Mr. Clarke is manager of the company's Swansea office, where he is be to succeeded by Mr. K. M. Fox.

SIR W. G. ARMSTRONG WHITWORTH AND CO. (IRONFOUNDERS), Ltd., and Jarrow Metal Industries, Ltd., have decided to form a local board of directors under the Jarvis Industries Group. The local directors are Mr. R. H. Philip, Mr. C. Lashly, Mr. T. Stonehouse, Mr. J. Bell, Mr. E. B. Ellis, Mr. J. H. Barrett, Mr. E. Story, Mr. R. Johnson and Mr. J. L. Smith.

British Patent Specifications

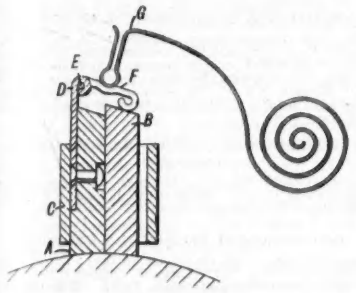
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

681,936. July 26, 1950.—Brush and Commutator or Slip Ring Gear, The National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Robert Frank Sims.*)

One form of the invention illustrated by the drawing consists of two thin brushes *A* and *B* of the same shape and dimensions, arranged side by side in tandem in sliding contact with one another in a single holder *C*. At the face remote from the brush *B* the brush *A* is recessed to accommodate

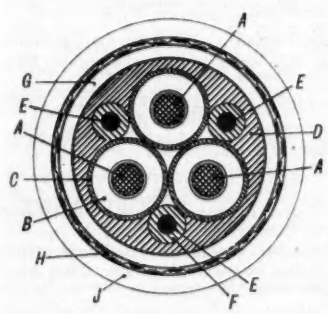


No. 681,936

one member *D* of a metal hinge, which is secured rigidly to the brush by a rivet. The hinge member extends just beyond the outer end of the brush to support the pin *E* of the hinge and the corresponding end of the other member *F* of the hinge clear of the brush *A*. The second hinge member extends from the hinge pin over the brush *B* and at its free end is curled or turned inwardly upon itself to bear upon the outer end of the brush *B*. A single spring *G* bears upon an indent in the outer face of the hinge substantially midway between the pin and the inturned end. Instead of the spring shown a spring-loaded pressure arm may be employed. In a modification the two brushes are accommodated in two separate holders.—*October* 29, 1952.

681,899. August 15, 1951.—High Tension Cable Installations, Siemens-Schuckertwerke, Aktiengesellschaft, Berlin and Erlangen, Germany.

The invention relates to electric high tension cable installations having protective and supervisory arrangements. Referring to the drawing (by way of example), the individual cores *A* to be operated at high tension are each provided with rubber insulation *B*. Each core has above the insulation a conductive covering *C* of rubber mixture containing conductive materials, such as lamp black or graphite. The cores thus built up are then provided with an inner jacket *D* filling the interspaces, and also consisting of conductive rubber. To increase the longitudinal conductivity, there are inserted in the spaces between the main conductors metal wires *E*, each of which is provided with a layer *F* of conductive rubber. The layers and the wires are all maintained at earth potential when the cable is in use. Over the inner jacket *D* lies a common insulating cover *G*, over which there is provided a further conductive layer *H*,



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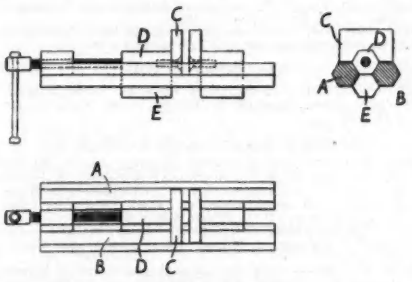
which, in this example, is fashioned in the form of a screening mesh formed of thin copper strands, and to which an auxiliary potential is applied. This layer is externally covered by the insulating outer jacket *J*, which is preferably formed of a rubber which has maximum resistance to abrasion and burns with difficulty. The protection of the high tension cable installation acts as follows. On occurrence of a fault in the insulation of a main core, a short-circuit is set up between the conductor *A* and the conductive covering *C* at earth potential by which it is surrounded. The cable installation is then disconnected by (for example) a leakage relay before a short-circuit can occur between two main conductors and dangerous arcing can occur. If, on the other hand, the external jacket *J* is damaged or destroyed to such an extent that the conductive covering H comes into contact with earthed external parts, the cable is also disconnected by a supervisory relay. This relay is actuated by a low auxiliary potential, for example 24V, applied to the conductive covering. The same supervisory arrangement also disconnects the cable if, as a result of external action, for example due to crushing, the external protective jacket *J* is not damaged, but the inner protective insulating layer *G* is deformed to such an extent that a conductive contact is brought about between the conductive layer *H* maintained at an auxiliary potential and the conductive inner jacket *D* maintained at earth potential. It is preferable in this case, in order to cause the relay to respond before damage occurs to the inner cable structure, especially the main cores, to construct the inner insulating jacket *G* of a material of lower mechanical strength than the remaining layers of the cable, for example, of sponge rubber or a mixture of regenerated rubber.—*October* 29, 1952

WORKSHOP TOOLS AND APPLIANCES

681,620. March 29, 1950.—Means for Sliding Support of a Tool or Machine Part, William Horace Kennedy, Station Works, West Drayton, Middlesex.

In the drawings, a hand vice embodying the invention is shown. It comprises a pair of hexagonal parallel spaced rods *A* and *B* which support the vice jaws. The vice has an adjustable jaw *C* which is mounted on a short rod *D* of the same cross section as the rods, the opposite flat sides making sliding contact with the adjacent flat sides of the rods. The rod is held in position by a further short hexagonal rod *E* which is secured to its under side, and has flat sides which make sliding engagement with the



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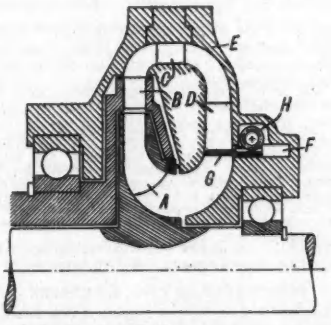
adjacent flat sides of the lay rods. With this arrangement the vice jaw can readily slide along the rods and the necessity of machining slots or guideways in the rods for the jaw to run in is obviated and the cost of production accordingly reduced. The general construction is shown in the drawings, and the specification also describes a tube-bending machine built on the same principle.—*October* 29, 1952.

HYDRAULIC MACHINERY

681,594. February 1, 1951.—A Turbo-Converter with Ring Valve, J. M. Voith G.m.b.H., Heidenheim (Brenz), Germany.

The invention is based on the discovery confirmed by trials that it is possible to regulate the power consumption of a converter and its transmission efficiency with approximately equal effect by inserting



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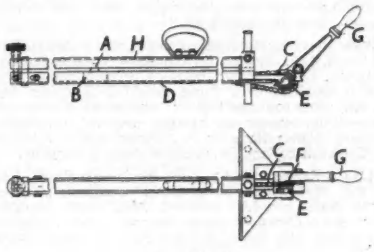
a ring valve at any desired part of the circuit. The turbo-converter shown in the drawing comprises a pump rotor *A*, a turbine rotor *B*, and two guide vane rings *C* and *D*, which are mounted in the fixed casing *E*. Adjacent the second guide vane ring *D* there is formed in the casing a cylindrical ring chamber *F*, in which a ring valve *G* is mounted for axial sliding movement. The ring valve, when it is in the operative position, obstructs the fluid circulation in the converter after the second guide vane ring. In order to provide for the actuation of the ring valve it is formed at one or more parts of its outer circumference with gear teeth, which are adapted to mesh with a gear pinion *H*. As the drawing shows, the entire ring valve is made cylindrical. Only the thin, completely smooth valve part of this ring valve is adapted, in the operative position, to project into the liquid circuit, and the inner end almost completely closes the ring slit in the casing when the ring valve is in the withdrawn inoperative position. The radial dimension of the valve is so small that practically the whole lies in a space of uniform pressure. Modified designs are also shown in the specification.—*October* 29, 1952.

CONVEYORS AND TRANSPORTERS

681,591. January 12, 1951.—Cutting Device for Conveyor Belts, Curt Matthael, Bieberer Strasse 215, Offenbach a.M., Germany.

The invention relates to cutting devices for underground mine conveyor belts, consisting of rubber with a fabric core. Referring to the drawings, a double-edged knife *A* is mounted on a sliding block-



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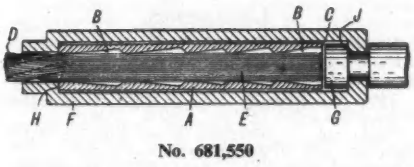
shaped support *B*, which is inserted into an endless chain *C*. The chain is actuated by rotation of a ratchet wheel *E* mounted on a shaft which also carries a toothed wheel *F* of the endless chain. The ratchet wheel is actuated by a hand lever *G* through a spring pawl or catch. Corresponding to the position of the spring pawl, the knife is guided to the right or to the left of the "U"-shaped bar *D*, respectively. A "U"-shaped upper bar or rail *H* serves to clamp the conveyor belt during the cutting operation.—*October* 29, 1952.

MISCELLANEOUS

681,550. July 6, 1949.—Means for Attaching Wire Ropes to Sockets, Le Grand, Sutcliff and Gell, Ltd., Southall, Middlesex. (*Inventor: Norman Fraser Brown.*)

As shown in the drawing, the wire rope ferrule comprises a tubular sleeve *A* having a cylindrical outer surface. The internal surface of the sleeve is formed with five axially-spaced recesses *B*, which are substantially frusto-conical in shape with their bases directed towards the outer end *C* of the sleeve.



No. 681,550

The ferrule is attached to a wire rope *D* by filling the recesses with a suitable low-melting point metal which bonds itself to the rope, and by extending into the recesses *B* forms a series of conical or wedge-shaped portions each of which will carry part of any load applied to the ferrule. In attaching the ferrule it is slipped over the end of the rope *D* and positioned to expose the end portion *E*, which is then unlaid, the hemp core removed and the strands straightened to form a "brush" which is cleaned. The ferrule is then slipped back over the "brush" and molten low-melting point babbitting metal is then poured into the outer end *C* of the ferrule *A* which is inverted for this purpose. As shown in the drawing, the rope socket comprises a split tubular member *F* assembled round the ferrule *A* and the head *G* of a service tool or the like. The member *F* is provided with a shoulder *H* engaging over the end of the ferrule and a shoulder *J* engaging under the head of the tool. The socket is secured to the ferrule by clamping rings or any other convenient means.—*October* 29, 1952.

Launches and Trial Trips

ABEILLE XXVI, salvage tug ; built by the Chantier de Normandie of the S.A. des Chantiers et Ateliers de Saint-Nazaire Penhoet for the Societe Cherbourgeoisi de Remorquage et de Sauretage ; length between perpendiculars 160ft 9in, breadth moulded 32ft, depth 16ft 1in, draught loaded 15ft 5in, speed 15 knots ; radius of action 9000 miles ; two pressure-charged four-stroke M.A.N. diesel engines driving single shaft through Vulkan clutches and reduction gearing, each engine has six cylinders 460mm diameter by 660mm stroke, 1500 b.h.p. at 250 r.p.m. Trial October.

HEMBO, tug ; built by Philip and Son, Ltd., for the Union Lighterage Company, Ltd.; length between perpendiculars 75ft, breadth 20ft, depth moulded 10ft 6in; Ruston and Hornsby 7V.G.B.M. diesel engine, 520 b.h.p. at 430 r.p.m. Launch, October 31st.

MARWICK HEAD, coaster ; built by Henry Robb, Ltd., for A. F. Henry and MacGregor, Ltd. ; length between perpendiculars 250ft, breadth moulded 40ft, depth moulded to upper deck 18ft 6in, and to raised quarter deck 22ft 6in, deadweight 2250 tons on 17ft draught, designed speed 10·5 knots ; one eight-cylinder British Polar diesel engine, 1280 b.h.p. at 250 r.p.m., two 100kW and one 30kW diesel generators. Trial, October.

DAGLAND, oil tanker ; built by Swan, Hunter and Wigham Richardson, Ltd., for Aktieselskabet Ocean, Norway ; length between perpendiculars 500ft, breadth moulded 65ft 6in, depth moulded 37ft 6in, deadweight 15,560 tons, load draught 29ft 2½in, service speed 13 knots ; ten cargo tanks divided by two longitudinal bulkheads, two pump rooms, four steam-driven horizontal duplex pumps, steam deck machinery ; two 110kW steam-driven generators, one 75kW diesel generator ; Wallsend-Doxford two-stroke oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5100 b.h.p. at 105 r.p.m., two multi-tubular boilers. Trial, November 4th.

CYMRIC, refrigerated cargo liner ; built by Harland and Wolff, Ltd., Belfast, for the Shaw Savill and Albion Company, Ltd. ; length between perpendiculars 481ft, breadth moulded 69ft, depth moulded to shelter deck 41ft 6in, gross tonnage 10,800; two Harland and Wolff single-acting, two-stroke, opposed piston diesel engines, cylinders 750mm diameter by 2000mm combined stroke, two Clarkson boilers, four 320kW diesel generators.

M.S.C. RANGER, tug ; built by Henry Robb, Ltd., for the Manchester Ship Canal Company ; length overall 95ft, breadth moulded 24ft, depth moulded 12ft ; two Crossley diesel engines, four cylinders, total output 1200 b.h.p. at 250 r.p.m. Launch November 4th.

Contracts

JOHN HOWARD AND CO., Ltd., has received from the Kuwait Government a contract to the value of £2,000,000, to build a technical training college which, when completed, will have accommodation for 1000 students.

TAYLOR WOODROW CONSTRUCTION, Ltd., has been awarded a contract worth over £1,500,000 for the construction of foundations and aqueducts for a power station at Castle Donington, Derbyshire. The contract has been placed by the British Electricity Authority, East Midlands Division, and is to be completed by the end of 1954 or early in 1955. The consulting engineers are Freeman, Fox and Partners.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received an order for nine 20kW high-frequency radio transmitters to be installed at Paradys, near Bloemfontein. The system will give complete broadcasting coverage to the Union of South Africa. Six of the transmitters, in two groups of three, will be used to cover the English, Afrikaans and commercial services on two alternative frequencies. Two transmitters will be used for the African service and the remaining equipment is to serve as a standby for all services.

Catalogues

J. H. FENNER AND CO., Ltd., Hull.—Vee belt catalogue.

GANDY, Ltd., Wheatland Works, Wallasey.—Leaflet describing nylon drop stamp belting.

ANDERTON SPRINGS, Ltd., Bingley, Yorks.—Data sheets giving details of type " 1500 E " clips.

ALAR, Ltd., 3, Albemarle Street, London, W.1.—Data sheet LM–13, *Aluminium Casting Alloy*.

SIGMUND PUMPS, Ltd., Team Valley, Gateshead.—Leaflet giving details of the type " A-N " chemical pump.

MURAD DEVELOPMENTS, Ltd., Stocklake, Aylesbury, Bucks.—Leaflet giving details of the model 1A capstan lathe.

CAMERER CUSS AND CO., 54–56, New Oxford Street, London, W.C.1—Catalogue of stop-watches and chronographs.

JENKS BROTHERS, Ltd., Britool Works, Bushbury, Wolverhampton.—Britool catalogue of socket and similar wrenches.

CHARLES WESTON AND CO., Ltd., Irwell Bank Works, Douglas Green, Pendleton, Salford, 6.—Brochure illustrating split seals.

FUNDITOR, Ltd., Woodbridge House, 3, Woodbridge Street, London, E.C.1.—Illustrated leaflet describing industrial electric furnaces.

THE D.P. BATTERY COMPANY, Ltd., Bakewell, Derbyshire.—Publication No. DP 816, entitled *DP Kathanode Diesel Engine Starting Batteries*.

HIRELITE, Ltd., 115/117, Cannon Street, London, E.C.4.—Brochure describing a service of industrial and commercial lighting installations.

THE STABILAG COMPANY, Ltd., 1, Broad Street Buildings, Liverpool Street, London, E.C.2.—Pamphlet entitled *Infra-Red Plant Heating*.

RAGLAN ENGINEERING COMPANY (NOTTM.), Ltd., Raglan Street, Nottingham.—Illustrated leaflet describing the " Little John " ‡in capstan lathe.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Illustrated booklet dealing with drying in industry.

KEITH BLACKMAN, Ltd., Mill Mead Road, Tottenham, London, N.17.—Catalogue illustrating the larger types of " Tornado " fan engineering equipment.

THE STANDARD AND POCHIN BROS., Ltd., Ervington Valley Road, Leicester.—Publication No. 177, detailing the paddle rotor " Uniform " pulley-mounted fan.

HEAT AND AIR SYSTEMS, Ltd., Coastal Chambers, 172, Buckingham Palace Road, London, S.W.1.—Publication describing enamelling and stoving ovens.

ROSE, DOWNS AND THOMPSON, Ltd., Old Foundry, Hull.—List No. 49, describing the rolls used in the crushing of oil seeds and nuts prior to oil extraction.

ROCKWELL MACHINE TOOL COMPANY, Ltd., Welsh Harp, Edgware Road, London, N.W.2.—Bulletin describing the British-built " American " three-way broaching machines.

AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., Strowger Works, Liverpool, 7.—Publications Nos. 1151 and 1187, dealing with signal indicators suitable for offices, hospital wards, &c., and automatic dial telephones.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 21st.—LIVERPOOL BRANCH : Lecture Theatre Service Centre, 9, Whitechapel, Liverpool, " Developments in Fluorescent Lighting and Dimming Control," Dr. Ballin, 7.30 p.m.
Mon., Nov. 24th.—BOURNEMOUTH BRANCH : Grand Hotel, Fovale Road, Bournemouth, " Formation of Ducts in Concrete Non-Expendable Material," 8.15 p.m.
Tues., Nov. 25th.—YORK BRANCH : Creamery Restaurant, Pavement, York, " Production and Application of Toughened Glass," P. M. Davidson, 7.30 p.m.
Wed., Nov. 26th.—LUTON BRANCH : George Hotel, Luton, " A Camera and the Engineer," G. E. Whalley, 8 p.m.

ENGINEERS' GUILD

Wed., Nov. 26th.—W. MIDLANDS BRANCH : Imperial Hotel, Temple Street, Birmingham, Address by A. H. S. Waters, 6.45 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 24th.—LEEDS CENTRE : Lighting Service Bureau, 24, Aire Street, Leeds, 1, " Brightness Engineering," W. Robinson, 6 p.m.——LEICESTER CENTRE : E. Midlands Electricity Board, Charles Street, Leicester, " Black Light : Its Effect and Applications," H. L. Privett, 6.30 p.m.
Tues., Nov. 25th.—CARDIFF CENTRE : S. Wales Electricity Board, Cardiff, " Lighting of Modern Ocean Liners," T. Catten, 5.45 p.m.
Wed., Nov. 26th.—LONDON CENTRE : Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, Discussion on " Home Lighting," 6 p.m.——SWANSEA GROUP : Minor Hall, Y.M.C.A., Swansea, " Lighting of Modern Ocean Liners," T. Catten, 6 p.m.
Thurs., Nov. 27th.—BIRMINGHAM CENTRE : " Regent House," St. Philip's Place, Colmore Row, Birmingham, " Lighting of Docks and Railway Marshalling Yards," W. T. F. Souter, 6 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., Nov. 27th.—S. YORKSHIRE BRANCH : Grand Hotel, Sheffield, " Radiology and Its Uses in Steel Works," F. Hinsley, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Sun., Nov. 23rd.—Midland Hotel, Manchester, " Production Control," J. F. Hull, 2.30 p.m.

INSTITUTE OF FUEL

Tues., Nov. 25th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, " Experiments on the Sampling of Coal," E. H. M. Badger, 5.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Nov. 21st.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, " The Vertical Reference in Navigation," W. A. W. Fox and D. Barnett, 5 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Nov. 25th.—N.E. CENTRE : County Hotel, Nevile Street, Newcastle upon Tyne, " Fleet Maintenance on a Large Scale," W. R. T. Thomas, 7 p.m.
Thurs., Nov. 27th.—WESTERN CENTRE : Grand Hotel, Bristol, Brains Trust, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

To-day, Nov. 21st.—N.E. CENTRE, GRADUATES' AND STUDENTS' SECTION : Chemical Engineering Department, Stephenson Building, Claremont Road, Newcastle on Tyne, " Filtration," Professor Shelby-Miller, 6.15 p.m.——N.W. CENTRE, GRADUATES' AND STUDENTS' SECTION : Queen Hotel, City Road, Chester, " Problems of Plant Design for Fluidised Processes," S. A. Gregory, 7 p.m.
Wed., Nov. 26th.—GRADUATES' AND STUDENTS' SECTION : Visit to Kestner Evaporator Company, Ltd., New Cross, 2.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 25th.—ROAD SECTION : Great George Street, Westminster, London, S.W.1, " Soil Stability Problems in Road Engineering," Rudolph Glossop and G. C. Wilson, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 24th.—RADIO SECTION : Savoy Place, London, W.C.2, " Recent Progress in Radar Duplexers, with Special Reference to Gas Discharge Tubes," P. O. Hawkins, 5.30 p.m.
Tues., Nov. 25th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, " The Measurement of Very Small Direct Currents," M. W. Jervis, 7 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, " A Logical Approach to the Problems of Electric Space Warming," D. H. Parry, 6.30 p.m.
Wed., Nov. 26th.—SUPPLY AND MEASUREMENTS SECTION : Savoy Place, London, W.C.2, " The Electrolytic Analogue in the Design of High-Voltage Power Transformers," D. McDonald ; " The Accurate Mapping of Electric Fields with an Electrolytic Tank," K. F. Sander, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Nov. 26th.—W. OF SCOTLAND BRANCH : Engineering Centre, 351, Sauchiehall Street, Glasgow, C.2, Talk by Det. Sup. McKelvie, 7.30 p.m.
Thurs., Nov. 27th.—N.W. BRANCH : Engineers' Club, Albert Square, Manchester, " Measurement Standards," J. Parker, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 2nd.—39, Elmbank Crescent, Glasgow, " Instruments and Technique in Vibration Research," D. S. Gordon, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 21st.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, Discussion on Recent Developments in the Machinability of Steel, K. J. B. Wolfe, 5.30 p.m.
Fri., Nov. 28th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, " The Athlone Fellowship Scheme for Training Canadian Graduates in Great Britain," W. Abbott, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Nov. 26th.—INFORMAL MEETING : Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, " Mechanical Aids," G. A. Robert, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 21st.—N.E. GRADUATE SECTION : N. of England Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, " Question Time," 7 p.m.
Mon., Nov. 24th.—SHEFFIELD SECTION : Royal Victoria Station Hotel, Sheffield, INFORMAL MEETING on " Apprentice Training," 6.30 p.m.
Tues., Nov. 25th.—LUTON SECTION : Small Assembly Room, Town Hall, Luton, " A Recent Advance in Plastics," E. M. Elliott, 7.15 p.m.——WOLVERHAMPTON GRADUATE SECTION : Star and Garter Hotel, Victoria Street, Wolverhampton, " Textile Production Engineering," G. A. D. Coghlan, 7.30 p.m.
Wed., Nov. 26th.—SHREWSBURY SECTION : The Walker Hall, Technical College, Shrewsbury, " History and Development of the Tube Industry," C. G. Goldsworthy, 7.30 p.m.——LINCOLN SECTION : Staff Canteen, Ruston and Hornsby, Ltd., Boultham Works, Lincoln, " Production Management's Responsibility for Productivity," B. H. Dyson, 7.30 p.m.
Thurs., Nov. 27th.—LONDON SECTION : Royal Empire Society, Northumberland Avenue, London, W.C.2, " Management Accounting and the Production Engineer," H. H. Norcross, 7 p.m.——S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, " Metal Finishing." Talks and Discussions on Anglo-Productivity Report, 6.45 p.m.——WESTERN GRADUATE SECTION : Belle Vue Hotel, Cheltenham, " Improvements and Their Hindrances," C. R. Whitaker, 7.30 p.m.
Sat., Nov. 29th.—YORKSHIRE GRADUATE SECTION : Great Northern Hotel, Leeds, " Measurement of Productivity," S. M. Maude, 2.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Nov. 24th.—Engineers' Club, Albert Square, Manchester, " Rubber Based Shoe Soling Materials," D. Grimwade, 6.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., Nov. 26th.—MIDLAND COUNTIES BRANCH, GRADUATES' AND STUDENTS' SECTION : Room 129, Civic Centre, Birmingham, " Boreholes in the Midlands for Water Supply and Foundations," E. T. Edwards, 6.30 p.m.
Thurs., Nov. 27th.—JOINT MEETING with British Section of the Société des Ingenieurs Civils de France, 11, Upper Belgrave Street, London, S.W.1, " An Introduction to Vacuum Concrete," Monsieur Lévant, 5.55 p.m.
Fri., Nov. 28th.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, " Tubular Structures," E. McMinn, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 21st.—Townsend House, Greycoat Place, London, S.W.1, " Some Comparisons Between Shell and Water-Tube Boilers," J. N. Williams, 7 p.m.
Sat., Nov. 22nd.—N.W. SECTION : Geographical Society, 16, St. Mary's Parsonage, Manchester, " Industrial Instrumentation," F. H. Auger, 2.30 p.m.
Fri., Nov. 28th.—Townsend House, Greycoat Place, London, S.W.1, Annual General Meeting, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 28th.—Engineers' Club, Albert Square, Manchester, " Economic Review," A. Elliott, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 28th.—Mining Institute, Newcastle upon Tyne, " Springs," W. E. Frost, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Nov. 27th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, " Photoelasticity and Aircraft Research," H. T. Jessop, 6 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Nov. 25th.—Grand Hotel, Sheffield, " Survey of the Use of the Direct-Reading Spectrometer in America," G. E. Speight, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Dec. 1st.—Geological Society, Burlington House, Piccadilly, London, W.1, " The Fatigue of Metals : Facts and Theories Reviewed," B. R. Byrne, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Nov. 25th.—Manson House, Portland Place, London, W.1, A Symposium on Control Valves, " Some Theoretical Aspects," A. R. Aikman ; " Design," H. R. Walton ; " Application," B. W. Balls, 6.30 p.m.